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A COURSE

IN

Botany and Pharmacognosy

By

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PREFACE.

While in the different sciences there are a large number of text-books treating of the fundamental principles thereof, still it does not seem desirable to employ the same manner of treatment in teaching different classes of students whose ultimate aims are in many instances quite diverse. This knowledge should be adapted to the particular needs of the students in the different departments, and for this reason there are likely to be as many different classes of text-books as there are sub-departments of each of the sciences.

This book is written to meet the individual needs of the author in his work as a teacher of botany and pharmacognosy, and this statement, it is hoped, will at once explain both its limitations and scope.

The subject of morphology is more or less extensively treated, particularly that of the plant cell, because this knowledge is of fundamental importance in the study of vegetable drugs. A knowledge of outer morphology is important in the description and identification of crude drugs, and a knowledge of inner morphology becomes of prime importance in the study of powdered drugs, as well as of value, in some instances, in the study of crude drugs.

The material used in connection with the preparation of the text has been largely furnished by medicinal plants and the commercial vegetable drugs. It is interesting to note what a rich field is here at command, and which may be readily drawn upon, for the study of the many diversified forms of cells and cell-contents as well as the study of the morphology of the different parts of the plant.

It should be stated that, in the main, the system of nomenclature adopted by Engler and Prantl is followed. Names of authors used in connection with plant names are omitted, however, except in special cases, for several reasons, which need not be considered here. The names of plants and genera are for the most part printed in italics; the names of drugs and the common names of plants being printed in the regular type of the text.

While this book is intended to be used in connection with the lectures given by the author, it is also to be employed in connection with a laboratory course. The illustrations in Part IV are intended to elucidate or bring out those fundamental points in morphology which are essential in the study of vegetable drugs. It may be said, however, that at the same time the important characteristics of a large number of vegetable drugs, particularly of the powders, are also illustrated.

In conclusion, the author acknowledges his indebtedness to Miss Florence Yaple, Philadelphia, for invaluable services in the preparation of this book for publication.

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PART I.

PLANT MORPHOLOGY.

CHAPTER I: THE CELL.

A. INTRODUCTORY.

Upon making a section of any of the flowering plants[1] and examining it by means of the microscope, it will be found to consist of a number of compartments, or cells, as they were first termed by Robert Hooke, in 1667. While they were more or less carefully studied by Malpighi and other investigators, it was not, however, until 1838 and 1839 that Schleiden and Schwann, respectively, demonstrated that the tissues of both plants and animals are made up of these units.

A normal living cell may be said to consist of a wall and contents, although in some of the lower orders of plants the wall may be wanting. The wall, as well as the contents of the cell, consists of a number of substances, and because of the primary importance of the cell-contents in the development of the plant, their nature and composition will be considered first.

[1] The flowering plants, or Phanerogams, are those plants which produce true seeds; they are divided into two main groups: (1) Angiosperms and (2) Gymnosperms.

The Angiosperms embrace those plants in which the seeds are enclosed in a covering, or ovary, and which produce what are generally known as flowers.

The Gymnosperms include those plants in which the seeds are situated at the base of flattened scales. All the cone-bearing plants, as pines, hemlocks, etc., belong to this group.

The cell-contents naturally group themselves into two distinct classes: one in which the life-processes of the plant are manifested, and which may be looked upon as constituting plant organs, and another which are the direct or indirect products of these. The former may also be termed the organized cell-contents, and include the protoplasm, nucleus and plastids. The other class consists of the unorganized cell-contents, and includes the various carbohydrates, calcium oxalate, tannin, aleurone, oil, and a number of other substances.

B. ORGANIZED CELL-CONTENTS.

PROTOPLASM.

Protoplasm was first accurately described by von Mohl, in 1846, who referred to it as "a mass of fibers, or a fibrous network, the meshes of which are filled with a fluid." About 1850 it was shown that the protoplasm of plants was the real seat of their vitality and activities, and about the same time a similar discovery was made in regard to the "sarcode" or primary substance of animals. The term protoplasm is now used to designate the fundamental living substance of both plants and animals.

Protoplasm occurs as a more or less semi-fluid, slimy, granular, or foam-like substance, which lies either close to the walls of the cell, as a relatively thin layer and surrounding a large vacuole of cell-sap, or from this protoplasmic layer threads or bands may extend to a central or excentral mass of protoplasm, in which a nucleus is usually embedded. As to the chemical composition, or even the physical structure, of living protoplasm, our knowledge is but fragmentary. With microchemical reagents it behaves like the albuminoids; and with staining agents certain

appearances are observed, which, however, may be due to postmortem changes.

NUCLEUS.

In the protoplasm of mature and active cells there is usually present a differentiated body, already referred to, which is known as the nucleus. It is a more or less spherical, ovoid, or narrow ellipsoidal body, consisting of a somewhat fibrous and granular substance, which is imbedded in a ground substance, the whole being surrounded by a membrane-like portion. While closely resembling the protoplasm, it may be differentiated by staining with iodine, borax-carmine or methylene green in acetic aid.

PLASTIDS.

The plastids, or chromatophores, are also differentiated bodies found in the protoplasm, and which are associated with it in the building up of complex organic compounds. They are found in all plants, with the exception of the fungi, and possibly some of the lower forms of algæ. According to the position of the cells in which they occur and the functions they are to perform, they vary in color—three distinct kinds being recognized. In the egg-cell and in the cells of roots, rhizomes, and seeds, the plastids are colorless and are called **leucoplastids.** When contained in cells which are more or less exposed to the light, they are known as **chloroplastids**, or chlorophyl grains. In other cases, independently of the position of the cells as to light or darkness, they may develop a yellowish or orange-colored principle, and are then known as **chromoplastids.**

The plastids consist of a protoplasmic-like substance, and vary in form from more or less spherical to polygonal or irregular-shaped bodies. They suffer decomposition much more readily than the nucleus, and are

found in dried material in a more or less altered condition.

The **leucoplastids** were first carefully studied by Schimper. Their chief function is that of building up reserve starches, and they may be best studied in the common potato tuber, rhizome of iris and the pseudo-bulbs of *Phajus grandiflorus.*

The **chloroplastids** occur in all the green parts of plants. They vary from 3 to 11 μ in diameter and are more or less spherical or lenticular in shape, except in some of the lower algæ. They are found in greater abundance in the cells near the upper surface of the leaf than upon the under surface, the proportion being about five to one. These grains upon close examination are found to consist of (1) a colorless stroma, or liquid, in which are imbedded (2) green granules; (3) colorless granules; (4) protein masses; (5) starch grains; and finally (6) a membrane surrounding the whole. The green granules are looked upon as the CO_2 assimilation[1] bodies; the colorless grains are supposed to assist in the storing of starch or in the production of diastase, the conditions for these processes being directly opposite, *i.e.*, when CO_2 assimilation is active, starch is stored, and when this process is not going on, as at night, diastase is produced and the starch is dissolved. The protein grains may be in the nature of a reserve material of the plastid and are also formed as a result of CO_2 assimilation.

CHANGES IN THE COLOR OF CHLOROPLASTIDS.

When the organized contents of the cell lose their functions, the membranes of the chloroplastids are

[1] The process of CO_2 assimilation consists in the taking up of the inorganic compounds CO_2 and H_2O and converting them into starch, the first visible product of constructive metabolism, oxygen being given off at the same time.

dissolved and the contents unite to form a shapeless mass in which the color changes to a dark green or brownish green, owing to the action of the cell-sap acid. The plastids may, however, retain much of their original color, and even shape, if the plant after being gathered is quickly dried, either in a current of dry air or between sheets of dry bibulous paper. If the temperature of the surrounding media be higher than the ordinary, a darkening of the specimen is likely to occur. If, on the other hand, the drying is performed in direct sunlight, the leaves will become light green or yellowish green, due to the transformation of the chlorophyll or green coloring substance into etiolin.

There are also seasonal changes in the color of the leaves, as in late summer, when the CO_2 assimilation process is less active or becomes suspended. The leaves change to a yellow, as in Liriodendron, or red, as in the maples, sumachs and others. This change in the color is due to the fact that the chlorophyl pigment is reabsorbed by the plant, and other pigments which were associated with it thus become conspicuous. The proportion of chlorophyl present in the plant in June and in late summer is about twenty-five to one. While the yellow color of autumn leaves is due to the yellow pigment, xanthophyll remaining, the red color is generally due, apparently, to the action of light and air upon the various tannin compounds, producing the tannin-reds.

Chromoplastids.—In many cases, as in roots, like carrot, or flowers and fruits, which are yellowish or orange-colored, there is present a corresponding pigment, which is contained in a narrow elongated plastid. Some of these pigments, as the carotin in carrot, have been isolated in a crystalline condition.

There are also colors found in plants other than those already described, which are not due to the pigments associated with plastids, but are caused by blue, violet or purplish coloring principles dissolved in the cell sap. The white appearance of flowers is attributed to the inclusion of air in the cell sap.

C. UNORGANIZED CELL-CONTENTS.

The unorganized constituents of plants may be said to differ from the organized cell-contents in two important particulars, namely, structure and function; that is, they are in the nature of direct or indirect products of the latter. For convenience in considering them here, they may be grouped as follows:

(1) Those of definite form which may be further divided into (a) those which are colloidal or crystalloidal, as starch and inulin; (b) those which are non-colloidal or crystalline, as the sugars, tannin, alkaloids, glucosides, calcium oxalate; (c) composite bodies, as aleurone grains, which are made up of a number of different substances.

(2) Those of more or less indefinite form, including gums and mucilages, fixed and volatile oils, resins, gum-resins, oleo-resins, balsams, caoutchouc, and also silica and calcium carbonate.

I. SUBSTANCES MORE OR LESS DEFINITE IN FORM.

(*a*) COLLOIDAL OR CRYSTALLOIDAL.

1. STARCH.

Starch is the first visible product of the constructive metabolism[1] of the plant. This product is found in

[1]By metabolism is meant those chemical changes in the organism whereby complex substances are formed from simpler materials, or even the elements themselves; or from complex compounds simpler ones are formed. The former is known as constructive

the chloroplastid, and is known as **assimilation starch.** The latter is changed into soluble carbohydrates by the aid of ferments and probably other substances, and in this form is transported to those portions of the plant requiring food. In many of the cells through which the solution of carbohydrates passes these substances may be transformed back into starch through the influence of the leucoplastids, and this product is known as **transitory starch.** The starch in the medullary rays and in other cells of the wood and bark of plants is of this character, and is distinguished by being in the form of rather small and nearly spherical grains. In rhizomes, tubers, bulbs and seeds another kind of starch is produced by the leucoplastid, which differs from transitory starch in that the grains are, as a rule, quite large, and possess more or less distinct characteristics for the plants in which they are found. Starch of this kind is spoken of as "depot," "storehouse," or, more frequently, as **reserve starch.**

Occurrence.—Starch is found in most of the algæ and many of the mosses, as well as in the ferns and higher plants. The amount of starch present in the tissues of plants varies. In the root of cassava as much as 70 per cent. has been found. This constituent also varies in amount according to the season of the year. Rosenberg has observed that in certain perennial plants there is an increase in the amount of starch during the winter months, whereas in other plants it decreases or may entirely disappear during this period. In the latter case, from six weeks to two months in the spring are required for its re-formation, and about an equal period is consumed in the fall for its solution.

metabolism, and is illustrated in the formation of starch from carbon dioxide and water. The latter is known as destructive metabolism, as when sugar is changed into alcohol and carbon dioxide.

Structure and Composition.—The formula which is generally accepted for starch is $(C_6H_{10}O_5)_n$, this being recognized by Pfeffer, Tollens and Mylius. It is supposed that the molecular composition is quite complex, the grain being composed of different single groups of $C_6H_{10}O_5$ or multiples of the same. While this formula may be accepted in a general way, still it has been shown that there are at least two substances which enter into the composition of the starch grain, and more recent studies tend to show that it is in the nature of a sphero-crystalloid, resembling inulin in some respects. The starch grain has an interesting structure. In form it is more or less spherical or polygonal; has a more or less distinct marking known as the "hilum," "nucleus" or "the point of origin of growth," and the substance is distributed in more or less distinct layers or lamellæ.

While starch grains usually occur singly, they are not infrequently found in groups of two, three or four grains, when they are spoken of as two-, three-, or four-compound. In some of the cereals, as rice and oats, they are 100-compound or more. The individuals in compound grains are in some cases easily separated from one another. This occurs frequently in the mounting of specimens, and is especially noticeable in the commercial starches.

The various commercial starches are in the nature of reserve starches and may be distinguished by the following characteristics:

(1) The shape of the grain, which may be spherical, ellipsoidal, ovoid, polygonal, or of some other characteristic form.

(2) The size of the grain, which varies from 1 or 2 μ to about 100 μ in diameter.

(3) The position of the point of origin of growth,

which may be central or excentral. In some cases there are apparently two points of origin of growth in a single grain, and it is then spoken of as "half-compound," as in potato.

(4) The shape of the point of origin of growth, which may be spherical, as in potato; cross-shaped, as in maranta; a three- or five-angled fissure or cleft, as in corn, or indistinct or wanting, as in wheat.

(5) The convergence of the lamellæ, which may be either toward the broad end of the grain, as in maranta, or toward the narrow end, as in potato. In most grains the lamellæ are indistinct or wanting, as in wheat and corn.

(6) Behavior toward dilute iodine solutions, the color produced varying from a deep blue in most starches to a red or yellowish red, as in the amylodextrin grains of mace.

(7) The temperature (45° – 77° C.) at which the "kleister" or paste is formed, and its consistency.

(8) The appearance as viewed by polarized light; the distinctness of the cross as well as the kinds of colors produced, varying considerably as Nichol's prism is revolved.

(9) Behavior toward various reagents, as chromic acid, calcium nitrate, chlor-zinc-iodide, diastase and various aniline stains, peculiarities of both structure and composition being manifested.

General Properties.—If starch is triturated with water and the mixture filtered, the filtrate does not give a reaction with iodine solution; if, on the other hand, the starch is previously triturated with sand and then with water, the filtrate becomes blue on the addition of iodine solution.

If dry starch and iodine are triturated together no color or, at the most, a faint blue color is produced;

whereas, if a little water is added and the trituration repeated, a deep blue color is immediately produced.

The blue color of starch solution and iodine disappears on the application of heat, but slowly returns on cooling the solution, but not with the same degree of intensity.

When starch is heated with glycerin it dissolves, and if alcohol is added to the solution, a granular precipitate is formed which is soluble in water, the solution giving a blue reaction with iodine.

When starch is heated with an excess of water at 100° C. for varying periods of time, it completely dissolves with the formation, first, of soluble starch, which gives the characteristic blue reaction with iodine; then the production of dextrin compounds, giving violet-red, reddish and yellowish reactions with iodine; finally, maltose and dextrose are produced, these giving no reaction with iodine, but reducing Fehling's solution. The ferments and dilute acids have a similar effect on starch. The dry heating of starch at temperatures of 150°–170° C. changes it to dextrin.

VEGETABLE DRUGS CONTAINING STARCH.

The more important vegetable drugs, including some of the commercial starches, are here grouped according to the size and shape, or other peculiarities, of the starch grains:

SIMPLE SPHERICAL GRAINS.

(1) Those not more than 5 μ in diameter: Cimicifuga,[1] cypripedium, frangula, hydrastis, leptandra, piper, prunus virginiana, quassia, quercus alba, rhamnus purshiana, spigelia, viburnum opulus and viburnum prunifolium.

(2) Those not more than 10 μ in diameter: Calamus, euonymus, gelsemium, granatum, quillaja, sanguinaria, serpentaria, tonka, ulmus, xanthoxylum.

[1] See Plant Names in Introductory to Part II.

(3) Those not more than 15 μ in diameter: Apocynum, cinchona colchici semen (in caruncle only), convallaria, sumbul, valeriana.

(4) Those not more than 20 μ in diameter: Glycyrrhiza, phytolaccæ radix.

(5) Those not more than 30 μ in diameter: Stillingia.

COMPOUND SPHERICAL OR POLYGONAL GRAINS.

(1) Two- to three-compound: Belladonnæ radix (5 to 15 μ), sas safras (7 to 20 μ), and veratrum viride (7 to 20 μ).

(2) Two- to four-compound: Aconitum (4 to 12 μ), cinnamomum (7 to 15 μ), colchici cormis (7 to 20 μ), ipecacuhana (4 to 14 μ), those of Carthagena ipecac being uniformly larger; krameria (20 to 30 μ), rheum (5 to 20 μ), and sarsaparilla (7 to 20 μ).

(3) Two- to six-compound: Podophyllum (5 to 12 μ).

(4) More than six-compound: Capsicum (3 to 7 μ), cardamomum 1 to 4 μ), cubeba (1 to 4 μ), gossypii radicis cortex (4 to 20 μ), mezereum (10 to 15 μ) myristica (5 to 7 μ), pimenta (7 to 10), and rubus (3 to 7).

ELLIPSOIDAL OR OVOID GRAINS.

(a) Althæa (10 to 20 μ), geranium (10 to 15 μ), glycerrhiza (5 to 10 μ), pareira (7 to 15 μ), physostigma (25 to 40 μ), stillingia (15 to 30 μ), strophanthus (2 to 4 μ), and zingiber (15 to 30 μ).

OTHER GRAINS OF CHARACTERISTIC SHAPE.

Calumba (25 to 35 μ), iris florentina (15 to 30 μ), and potato (75 to 110 μ).

ALTERED GRAINS.

Guarana (10 μ), and jalapa (15 to 35 μ and two- to three-compound), tragacantha (2 to 10 μ), turmeric in masses (70 to 140 μ).

Macis contains AMYLODEXTRIN grains, which give a reddish color with iodine.

VEGETABLE DRUGS WITHOUT STARCH.

The following are some of the drugs which do not contain starch:

Amygdala amara, A. dulcis, anisum, aurantii amari cortex, aurantii dulcis cortex, coffea, carum, caryophyllus, cocculus, colocynthis, conium, coriandrum, cydonium, gentiana, hæmatoxylon, illicium, lappa, limonis cortex, linum, nux vomica (except in pulp adhering to seed), pepo, pyrethrum, quassia, rhus glabra,

santalum rubrum, scilla, senega, sinapis alba, sinapis nigra, staphisagria, stamonii semen, taraxacum, triticum and vanilla.

Leaves, herbs and flowers do not, as a rule, contain reserve starch.

2. INULIN.

Inulin was first observed by Valentin Rose in 1814 in the root of *Inula helenium.* It appears to be an isomer of starch and occurs in solution in the cell sap of various members of the Compositæ and various other families, being found in lower orders of plants only in isolated cases.

It is stored chiefly in the parenchyma cells of the wood and bark of rhizomes, tubers and roots, being also found in the medullary ray cells. It occurs in a colorless, or yellowish, highly refractive, concentrated solution, about 30 per cent. being present in plants during the early fall and spring, when it exists in greatest amount. During winter and also during summer it is changed to lævulin.

According to Dragendorff there are two forms of inulin; one of which is amorphous and easily soluble in water, and another which is crystalline and difficultly soluble in water. The latter is probably, however, a modification of the former, and it is not unlikely that the various principles known as pseudoinulin, inulenin, helianthenin and synantherin are all modifications of inulin.

If inulin-containing plants are preserved in alcohol and examined by aid of the microscope, the inulin will be found to have separated in the form of sphere-crystalloids, which are attached to the cell wall; but if the material is first allowed to dry out, the inulin will be found in irregular, almost gum-like lumps, which are with more or less difficulty dissolved in water.

In the latter form inulin is found in the following drugs: Inula, lappa, pyrethrum and taraxacum.

(b) CRYSTALLINE OR NON-COLLOIDAL.

1. SUGARS.

The sugars constitute a group of non-colloidal or crystalline principles of wide distribution. They occur in the cell sap, from which by evaporation or on treatment with alcohol they may be crystallized out. Quite a large number of distinct principles belonging to this class has been recognized, of which the following may be mentioned:

Dextrose (grape-sugar or dextro-glucose) is found in sweet fruits, the nectaries of the flowers and stems and leaves of various plants. It crystallizes in needles and varies in amount from 1 to 2 per cent. (in peaches), to 30 per cent. in certain varieties of grapes. It also occurs in combination with other principles, forming the glucosides.

Lævulose (fructose, fruit-sugar or lævo-glucose) is associated with dextrose, occuring in some instances even in larger quantities than the latter.

Sucrose (saccharose or cane-sugar) is found rather widely distributed, as in the stems of corn, sorghum and the sugar-cane; in roots, as the sugar-beet; in the sap of certain trees, as sugar-maple and some of the palms; in the nectaries and sap of certain flowers as fuchsia, caryophylllus and some of the cactaceæ; in seeds, as almond and chestnut, and in various fruits, as figs, melons, apples, cherries. In some plants, as in sugar-cane, the yield is as high as 20 per cent. It crystallizes in monoclinic prisms or pyramids and forms insoluble compounds with calcium and strontium.

Maltose is found in germinating cereals; it forms colorless needle-shaped crystals resembling those of dextrose, and forms compounds with calcium, strontium, barium and acetic acid.

Trehalose occurs in some fungi, as ergot and *Agari-*

cus muscarius—the latter containing as much as 10 per cent. in the dried plant.

Mannit occurs as needles or prisms and is found in the manna of *Fraxinus ornus* to the extent of 90 per cent. It is also found in some of the Umbelliferæ, as *Apium graveolens*, and in some of the fungi and sea-weeds.

Dulcit, which is closely related to mannit, is found in *Euonymus Europeus* and in most of the genera of the Scrophulariaceæ.

Melizitose is closely related to saccharose, and is found in the manna of *Pinus larix* and in the "Manna of India," the product of *Alhagi maurorum*.

Melitose is found in the manna from *Eucalyptus viminalis*, of Australia.

Gentianose occurs in the root of *Gentiana lutea*.

2. TANNIN AND TANNOIDS.

Tannins are astringent principles which produce blue or green precipitates with iron salts. The tannoids, in addition, precipitate albuminous compounds, and when applied to animal hides convert them into leather. These principles are widely distributed, occurring dissolved in the cell sap, in parenchyma cells or in distinct reservoirs or vessels, and vary in amount from 1 per cent. or less to as high as 70 per cent. in Chinese galls. Tannin occurs in relatively large amount in the following families: Anacardiaceæ, Cornaceæ, Cupuliferæ, Ericaceæ, Geraniaceæ, Hamamelidaceæ, Lythariaceæ, Leguminoseæ, Labiatæ, Plumbaginaceæ, Polygolaceæ, Polygonaceæ, Ranunculaceæ, Rosaceæ, Rubiaceæ, Salicaceæ, Saxifragaceæ. It not only occurs in the normal cells of plants but also in the excrescences known as galls, which are produced by the sting of various species of Cynips and Aphis.

The following microchemical reagents are used in the study of the tannins and tannoids: Carbonates of the alkalies, chromic acid, cupric acetate, iron acetate, limewater, methylene blue, potassium bichromate, sodium wolframate, ammonium molybdate, bromine water.

3. THE ALKALOIDS.

The alkaloids probably arise in the protoplasm and later appear in the cell sap in combination with various plant acids, as malic, tannic and others, and may be precipitated by the so-called alkaloidal reagents. They occur in greatest amount in those cells which are in a potential, rather than an active condition, being associated with starch, fixed oils, aleurone grains, and other reserve products, in the roots, rhizomes and seeds. By reason of their existing in greatest amount when the food materials are also in greatest abundance, they are considered by some authors as a means of protecting the latter, in the plant, from the attacks of animals. They are found in fruits in greatest amount during the development of the seed, but after the maturing of the latter they slowly disappear, as in poppy and conium. The occurrence of alkaloids in the walls of the cells of certain plants, as in nux vomica, is no doubt due to their imbibition by the wall as a result of pathological changes in the cell.

Many of the alkaloids which have been isolated by chemical means are in the nature of decomposition products of those already occurring in the plant, as certain of the alkaloids of tobacco, tea, coffee, cinchona, opium, etc. The alkaloids are of more frequent occurrence in the dicotyledons than in the monocotyledons, and are rather characteristic for certain groups, as those of the genus *Strychnos*, *Cinchona*, *Erythroxylon*, *Papaver*, etc.

While the microchemical study of the alkaloids requires considerable technic, still, in certain drugs, their detection is quite simple, as in nux vomica, strophanthus and hydrastis.

4. THE GLUCOSIDES.

The glucosides, like the alkaloids, are also probably formed in the protoplasm. They are compounds of glucose and other principles and may be classed among the reserve products. In some instances they readily separate in the plant cell, as hesperidin; while others give characteristic color-reactions, as crocin, salicin and coniferin, but in most instances they are either decomposed or the compounds which they form have no distinct microchemical value.

5. THE GLUCO-ALKALOIDS.

Gluco-alkaloids represent a class of compounds intermediate between the alkaloids and glucosides, possessing characteristics of each. To this class belongs achillein, found in various species of *Achillea* and probably solanin, found in a number of species of *Solanum*.

6. COLORING PRINCIPLES.

Coloring principles other than those associated with plastids occur dissolved in the cell sap or in ethereal oils, or are impregnated in or incrusted upon the cell wall. These principles may be divided according to the colors they naturally possess or acquire upon treatment with reagents, into the following groups:

(*a*) **Green coloring principles** as such are limited in number and include substances like digitoleic acid. Many of the essential oils are green in color, this being due probably to dissolved chlorophyl. A number of tannin principles acquire a green color with iron salts, as those of cinchona, quercus and krameria. In addi-

tion, quite a number of principles give a green color with various other reagents, as emetine with sulphuric acid, gelsemin with nitric acid, and the cinchona alkaloids with chlorine water and ammonia.

(*b*) **Yellow coloring principles** include a number of substances which occur in a crystalline condition, as chelidoxanthin from *Chelidonium majus*, quercitrin from *Quercus tinctoria.* A large number of volatile and fixed oils have a yellow color, which may be due to xanthophyl, or some modification of chlorophyl, as etiolin.

(*c*) **Red coloring principles** include some of the most important coloring substances of the arts, as crocin, alizarin, purpurin, morindin, hæmatoxylon, alkanna red, etc. The various tannins and tannoids yield upon oxidation red-coloring principles, and many of the alkaloids and other active principles produce red-colored compounds with various reagents.

(*d*) **The blue or purple coloring principles**, like the green, are limited in number, and are usually more or less difficultly soluble in water. They include some of the principal commercial dyes, as indigo blue. A number of the volatile oils of flowers have a blue color, as of *Matricaria chamomilla* and *Achillea millefolium,* this no doubt being due to the solvent action of the oil on the coloring principle of the flower.

7. CALCIUM OXALATE.

Calcium oxalate is found in many of the higher plants, and in the algæ and fungi as well; while in the mosses, ferns, grasses and sedges it is seldom found. It occurs in plants in crystals of either the monoclinic or tetragonal system. The crystals dissolve in any of the mineral acids without effervescence and are usually detected with dilute hydrochloric acid. The crystals of the monoclinic system are rather widely

distributed, while those of the tetragonal system are less frequent in their occurrence, being found in species of *Allium*, *Tradescantia* and *Begonia*, in *Paulownia imperialis* and in the Cactaceæ. The crystals belonging to the monoclinic system include a number of forms, as follows: (1) Rosette aggregates, or what are commonly termed rosette-shaped crystals; (2) prisms, pyramids and elongated or irregular hexagonal-shaped crystals; (3) crystal-fibers; (4) raphides; (5) cryptocrystalline crystals and (6) membrane crystals.

ROSETTE AGGREGATES OF CALCIUM OXALATE.

The rosette aggregates were first observed by Malpighi in 1687. They consist of numerous small prisms and pyramids, or hemihedral crystals more or less regularly arranged around a central axis, and have the appearance of a rosette or star. The development of these aggregates may be readily observed in the stem of *Datura Stramonium.* Crystals of this class are more widely distributed than any of the others, and are found in the following drugs, these being grouped according to the size of the crystal.

VEGETABLE DRUGS CONTAINING ROSETTE AGGREGATES OF CALCIUM OXALATE.

(*a*) Crystals not more than 7 μ in diameter: Anisum, calendula, carum, conium, coriandrum and fœniculum.

(*b*) Crystals not more than 15 μ in diameter: Caryophyllus and humulus.

(*c*) Crystals not more than 25 μ in diameter: Althæa, buchu, cannabis indica, cusso, eriodictyon, euonymus, frangula (prisms and pyramids also occur), gossypii radicis cortex, pimenta (usually smaller).

(*d*) Crystals not more than 35 μ in diameter: Jalapa, pilocarpus, stillingia, viburnum prunifolium and viburnum opulus (occasionally).

(*e*) Crystals not more than 100 μ in diameter: Chimaphila (40–60μ), geranium (45–70 μ) and rheum (50–100 μ).

MONOCLINIC PRISMS AND PYRAMIDS OF CALCIUM OXALATE.

Monoclinic prisms and pyramids are also widely distributed and are frequently so modified in form that they are of an elongated or irregular hexagonal shape. The crystals of this group are sometimes mistaken for silica, owing to the fact that in some instances the lumen of the cell is completely filled by the crystal, and the inner wall, having the contour of the crystal, it is impossible to determine whether the crystal is affected by the use of hydrochloric acid. It should be stated in this connection that silica never occurs as a cell-content in sharp angular crystals, but occurs either in more or less ellipsoidal or irregular hollow masses, or in somewhat solid, irregularly branching masses.

VEGETABLE DRUGS CONTAINING MONOCLINIC PRISMS OR PYRAMIDS OF CALCIUM OXALATE.

The following drugs are characterized by monoclinic prisms, and are grouped according to the size of the crystals.

(*a*) Crystals not more than 10 μ in diameter: Coca, hyoscyamus and uva ursi.

(*b*) Crystals not more than 20 μ in diameter: Calumba (in stone cells only), frangula, granatum (rosette aggregates also occur), hamamelis, quercus alba (rosette aggregates also occur), rhamnus purshiana and senna.

(*c*) Crystals not more than 30 μ in diameter: Cardamomum, eucalyptus, gelsemium, pimenta (occasional), prunus virginiana, quassia (cryptocrystalline crystals also occur), vanilla, viburnum opulus, viburnum prunifolium (occasional), and xanthoxylum.

(*d*) Crystals not more than 100 or 200 μ in diameter: Krameria (about 100 μ) and quillaja (35 to 200 μ).

CRYSTAL FIBERS.

In quite a number of drugs a single monoclinic prism occurs in each of the parenchyma cells adjoin-

ing the sclerenchymatous fibers, and to this single longitudinal row of superimposed cells the name crystal fiber has been applied.

They occur in the following drugs, which are grouped according to the size of the individual crystals:

(*a*) Crystals not more than 10 μ in diameter: Uva ursi.

(*b*) Crystals not more than 20 μ in diameter: Frangula, glycyrrhiza, hamamelis, haematoxylon, quercus alba and rhamnus purshiana.

(*c*) Crystals not more than 30 μ in diameter: Prunus virginiana.

(*d*) Crystals about 35 μ in diameter: Quillaja.

RAPHIDES.

Raphides was the name given by A. de Candolle (1826) to the groups of needle-shaped crystals found in various plants. These have been mistaken by several observers for calcium phosphate. Calcium phosphate, however, occurs in plants either in solution or in combination with protein substance. The cells containing raphides are long, thin-walled and contain sooner or later a mucilage, which arises from the cell sap and behaves with reagents much like cherry-gum. The cells are either isolated or occur in groups placed end to end, as in *Veratrum viride*, forming Hanstein's "Raphides Vessels." Raphides are found in the following drugs, and of the length given with each:

Belladonnæ folia (occasionally), cinnamomum, about 5 μ; convallaria, about 45 μ; cypripedium, about 40 μ; ipecacuanha, 20–40 μ; phytolaccæ radix, about 30 μ; sarsaparilla, 6–8 μ; scilla, 0·1 to 1·0 mm.; vanilla, about 400 μ; veratrum viride, about 45 μ.

CRYPTOCRYSTALLINE CRYSTALS OF CALCIUM OXALATE.

Cryptocrystalline crystals of calcium oxalate are exceedingly small (about .2 to 10 μ in diameter), deltoid or arrow-shaped, and so numerous as to

entirely fill the parenchyma cells in which they occur, giving the cells a grayish-black appearance and readily distinguishing them from other plant cells. Vesque supposed that they were tetrahedrons and termed them "Sable Tetraédrique." They are probably hemihedral forms of monoclinic crystals, inasmuch as monoclinic prisms occur in neighboring cells in the same plant or drug, as in stramonium, quassia, etc.

Cryptocrystalline crystals are found in the following drugs:

Belladonnæ folia, belladonnæ radix, cinchona, phytolaccæ radix and quassia.

MEMBRANE CRYSTALS.

There are several forms of crystals which may be included in this group. The so-called Rosanoff crystals consist of rosette aggregates attached to inward-protruding walls of the plant cell. These, however, do not concern us so much as the large monoclinic crystals which have a membrane (called by Payen "tissu special") surrounding them. The crystal first appears in the cell sap and then numerous oil globules appear in the protoplasm around it; later some of the walls of the cell thicken and grow around the crystal, which they finally completely envelop.

Crystals of this character and of the sizes given are found in the following drugs:

Aurantii amari cortex, 15–20 μ, and aurantii dulcis cortex, 20–30 μ.

VEGETABLE DRUGS WITHOUT CALCIUM OXALATE.

In the following drugs, calcium oxalate crystals are either wanting entirely or so few as to be without any diagnostic value:

Aconitum, apocynum, arnicæ flores, capsicum, chirata, cimicifuga, colchici cormis, colchici semen, colocynthis, cubeba, digitalis, eupatorium, gentiana, grindelia, hydrastis lappa, leptandra,

linum, lobelia, marrubium, mentha piperita, mentha viridis, mezereum, myristica, nux vomica, pareira, physostigma, piper, podophyllum, rhus glabra, rosa gallica, sabina, sanguinaria, santonica, sassafras, senega, serpentaria, sinapis alba, sinapis nigra, spigelia, staphisagria, strophanthus, sumbul, valeriana and zingiber.

Calcium oxalate crystals have been mistaken for crystalline sugar, and it should also be pointed out that some of the soluble carbohydrates, as hesperidin and inulin, may be mistaken for sphere-crystals of calcium oxalate, which are of rare occurrence. Some of the soluble carbohydrates, including inulin, occur in either sphere-crystals or irregular spherical aggregates, which are more or less easily soluble in water. They are found in buchu, hedeoma, inula, lappa, pyrethrum, taraxacum and triticum.

(*c*) COMPOSITE BODIES.

1. ALEURONE GRAINS.

Aleurone or protein grains consist of protein-crystalloids, globoids and a ground mass, the whole being inclosed by a membrane-like material. Calcium oxalate crystals may, or may not, be present; when they do occur, they are of special value in the study of the plants in which they are found, as in the fruits of the Umbelliferæ.

The aleurone grains arise in the cell sap, usually in that of seeds; the calcium oxalate, if present, separates first; then the globoids, which are small globular bodies composed of the double phosphate of calcium and magnesium, appear, after which the crystalloids arise, and finally, from the mother liquor, the ground mass separates, the whole becoming inclosed in a sac-like membrane.

Aleurone grains may be studied by taking advantage of the difference in solubility of the substances

composing them. The membrane is a plasma membrane and, while soluble in water, remains intact on examining sections in any of the fixed oils, as cottonseed oil. Usually seeds which contain aleurone are rich in fixed oils, and if this oil is first removed by placing fresh sections in alcohol, or alcohol and ether, the subsequent study is facilitated. If the sections thus treated are mounted in water, the membrane gradually dissolves, leaving the crystalloids, globoids and calcium oxalate. On adding a 0·1 to 1 per cent. solution of either sodium or potassium hydrate, the crystalloids dissolve, the globoids and calcium oxalate crystals remaining unaffected. The globoids may be dissolved by the use of a 1 per cent. acetic acid solution, or concentrated solutions of ammonium sulphate or monopotassium phosphate. The calcium oxalate remaining may then be treated with hydrochloric acid in the usual way.

SUBSTANCES WITHOUT DEFINITE FORM.

1. MUCILAGES AND GUMS.

By the terms mucilages and gums are meant those substances which are soluble in water, or swell very perceptibly in it, and which, upon the addition of alcohol, are precipitated as a more or less amorphous or granular mass. Mucilage originates in the plant as a cell-content, or as a modification of the wall. In the former case it arises as a product of the protoplasm, or it may be a disorganization product of some of the carbohydrates of the cell-contents. When it occurs as a "membrane mucilage," it owes its origin to several causes: either to a secondary thickening of or an addition to the cell wall, or a metamorphosis of it, at least in part. In the latter case it may arise either as a disorganization product of the

primary wall, or of the subsequent lamellæ making up the walls of the cells of the pith, medullary rays, parenchyma and other tissues, or it may arise as an intercellular substance.

The following is a classification of some plants, based upon the origin of the mucilage which they contain:

1. *Cell-Content Mucilage:*

   Corm of *Orchis* sp. (salep); rhizome of *Agropyrum repens*; bulb of *Urginea maritima;* bulb of *Allium* sp. (onion, garlic); stem, leaf and elements of flower, excepting stamens, of *Viola tricolor;* flower-stalks of *Hagenia Abyssinica;* pulp of fruit of *Musa paradisiaca* (banana); succulent plants, as aloe, etc.

2. *Cell-Membrane Mucilage:*

   a. *Secondary thickening of wall:* Root of *Althæa officinalis;* bark of *Cinnamomum* sp.; bark of *Rhamnus Frangula;* bark of root of *Sassafras varifolium;* inner bark of *Ulmus fulva;* leaves of *Barosma betulina*, and *B. crenulata;* seed-coat of *Cydonia vulgaris;* seed-coat of *Linum usitatissimum;* seed-coat of *Sinapis alba*, and *S. nigra*.

   b. *Metamorphosis of Cell wall:*

   α. Pith and medullary ray cells; *Astragalus* sp., yielding tragacanth.

   β. Parenchyma cells of wood and bark; cherry gum, yielded by some of the Amygdalaceæ.

   γ. Various cells of the bark; *Acacia Senegal*, yielding gum arabic.

   δ. Primary wall as intercellular substance; thallus of *Chondrus crispus* (Irish moss).

3. *Secreting Hairs (Drüzenzotten):*

   Leaf and calyx of *Viola tricolor* and leaves of *Coffea Arabica* (coffee) and of *Prunus avium*.

The origin of mucilage may be satisfactorily studied in the fresh corm of salep and in the root of althæa—in the former as a cell-content mucilage, and in the latter as a cell wall mucilage.

The mucilages are further distinguished by their behavior toward reagents; those which are colored blue by chlor-zinc-iodide, and are soluble in ammoniacal solution of cupric oxide, are known as cellulose mucilages. To this class belong the mucilages of the corm of salep and the seeds of cydonium. Most of the other mucilages, particularly the pectose-mucilages, are colored by alcoholic and glycerin solutions of the basic aniline dyes.

Mucilage which occurs in cells containing raphides is stained by corallin, which is not usually the case with the other mucilages.

2. OILS, RESINS AND ASSOCIATED PRODUCTS.

Oils, resins and their associated products, like the mucilages and tannins, are formed in the plant either as a result of the activities of the protoplasm, or by reason of abnormal or pathological changes in some of the constituents of the cell. The oils may be divided into two principal classes, namely, the reserve or fixed oils, which are more or less intimately associated with the protoplasm in fruits and seeds; and the volatile oils which occur in special cells or special reservoirs.[1] The vola-

[1] Oil is found either in special secretion cells or in special reservoirs. The former are large parenchyma cells, the walls of which are not infrequently suberized, and are found in rhizomes, as of calamus and ginger; in barks, as sassafras and cascarilla; in fruits, as capsicum, cubeba, piper and cardamomum. Oil secretion reservoirs are cavities formed either as a result of the enlargement of the intercellular spaces, caused by the separation of the cells, or by the disintegration of a number of cells. The former are spoken of as being schizogenous in origin, and the latter as lysigenous. These terms are also used to designate similar reservoirs holding mucilage, gum-resins and other products. The schizogenous reservoirs are of more common occurrence, and are found in inula, arnica rhizome, caryophyllus and the umbelliferous fruits and various leaves, as eucalyptus and pilocarpus.

tile oils are characteristic of some of the largest families of plants, as the Compositæ, Labiatæ, Rutaceæ and Umbelliferæ.

The oils, both fixed and volatile, are insoluble, or nearly so, in water; but are soluble in ether, carbon disulphide, chloroform, benzin, benzol and acetone. Most of the volatile oils and a few of the fixed oils are more or less soluble in alcohol. They are colored brownish or brownish black with osmic acid. The volatile oils are stained red by alcoholic solutions of alkanet, and some of them by certain of the aniline dyes, as fuchsin. The distinctive test for the resins is that when treated with concentrated aqueous solutions of copper acetate they acquire a green color. They are likewise stained blue by Hanstein's aniline violet. The reserve or fixed oils are liberated as oily globules on treatment of sections with sulphuric acid or concentrated chloral solution.

The volatile oils are not infrequently associated with other substances of the plant cell in varying proportions, as resins, gums, and certain acids of the aromatic series, as cinnamic and benzoic. Those products which consist chiefly of oil and resin are known as oleoresins, and include turpentine and copaiba; those consisting chiefly of gum and resin and containing but little volatile oil, are known as gum-resins, and include ammoniac, asafetida, galbanum and myrrh; oleoresins associated with aromatic acids are known as balsams, as balsam of tolu, balsam of Peru, storax and benzoin, which latter is usually called a balsamic resin.

3. THE FERMENTS OR ENZYMES.

The ferments or enzymes are apparently associated with the protoplasm, though, like other constituents, they may be found dissolved in the cell sap. In some

instances, as in the curing of tobacco and fermentation of vanilla, they may not only separate from the protoplasm, but may occur as a result of the decomposition or disintegration of the protoplasm itself. These principles are found in the cells of all the different parts of the plant, and may or may not be found in the cells containing the substances upon which they have a special action.

The microchemical study of the ferments is attended with certain difficulty on account of the lack of any specific reagents for their detection. The most that can be done is to study the products formed by their action upon certain other constituents of the cell. The ferments possess a peculiarity in that they require specific temperatures for their action, as, for example, emulsin or sinaptase, which decomposes a number of the glucosides, acts at a temperature of 35° to 40° C., while diastase, the ferment of germinating seeds, requires a somewhat higher temperature, namely, 50° to 70° C.

Ferments may be classified according as to whether they require oxygen or water for their reaction with other substances. The former are rather limited in number, and include laccase, found in the lacquer trees, and those which produce nitric fermentation in nature. The latter or hydrolytic ferments include diastase, which acts on starch, changing it into dextrose; inulase, which acts on inulin, producing lævulose; pectase, acting on pectin, producing vegetable jellies; emulsin or sinaptase, which decomposes amygdalin, arbutin, salicin and other glucosides; myrosin, which acts on the glucoside, sinigrin (potassium myronate), producing the essential oil of mustard and papain, the proteolytic enzyme of *Carica papaya*.

EXAMINATION OF CELL-CONTENTS.

I. Definite Form.			II. Without Definite Form.
A. Crystalline.	B. Crystalloids.	C. Non-crystalline.	
1. Calcium oxalate	4. Inulin	6. Starch	11. Protoplasm
2. Sugars	5. Protein crystalloids	7. Plastids	12. Inulin.
3. Alkaloids	(Either separate or in aleurone grains.)	in globules: 8. Oil	13. Mucilage
		9. Tannin.	14. Tannin
		10. Mucilage.	15. Resin

1. See page 25. 2. Crystalline in fresh material treated with alcohol; the glucoses give a reddish precipitate with Trommer's Reagent, consisting of solutions of copper sulphate (concentrated) and potassium hydrate (50 per cent.). 3. In specimens treated with acids, alkalies or alkaloidal reagents. 4. Sphere-crystalloids in fresh material treated with alcohol. 5. See page 30. 6. Generally colored blue with iodine solutions. 7. See page 11. 8. The essential oils are more soluble in alcohol and this distinguishes them from the fixed oils. 9. Gives bluish or blackish precipitate with solutions of ferric acetate, or a brownish precipitate with solutions of copper acetate. 10. Colored blue with solutions of methylene blue in alcohol or in glycerin. 11. Finely granular and colored yellowish or yellowish-brown with solutions of iodine or chlor-zinc-iodide. 12. In irregular masses in dried specimens. 13. See No. 10 14. In dried specimens tannin is sometimes associated with other substances as mucilages and resins, forming irregular masses, but it is usually absorbed by the cell wall. 15. Usually in yellowish or reddish masses, colored greenish with copper acetate solution, or reddish with tincture of alkanet.

D. THE CELL WALL.

I. ORIGIN AND COMPOSITION OF WALLS.

The cell wall is formed by the protoplasm, and by some authors is looked upon as a differentiated portion of the outer layer of the protoplasm, the latter ying close to the wall in a normal turgescent cell. The composition of the wall varies at different stages of the rowth of the cell, and according to the various functions it has to perform.

In order to thoroughly understand the nature and composition of the cell wall, it is necessary to study the origin and formation of new cells. Growth of the plant is attended not only by an increase in the size of the

cells, but by the division of these to form new cells. Cells that have the property to divide and form new cells are known as meristematic cells and constitute the **meristem.** The new and dividing walls resulting from the division of the cells consist of a number of substances: the first layer formed is apparently different from the subsequent layers and is known as the "middle plate," **middle lamella** or "intercellular substance." This layer is soluble in, or readily attacked by, solutions of the alkalies or solutions containing free chlorine. It is insoluble in sulphuric acid, and readily stained by the aniline dyes. While usually more or less permanent, this middle plate may be finally absorbed, as in the secreting hairs of kamala, or it may be changed into mucilage, as in chondrus, or transformed into pectin compounds, as in fleshy roots and fruits.

To this middle plate is added on either side by the newly formed cells a layer of substance closely resembling cellulose, this constituting the **primary membrane** or "primary lamella."

Still other layers may be added, consisting of one or more of the following substances: cellulose, or some modification of it; wax, silica or calcium oxalate, these layers constituting what may be termed the **secondary lamella.**

II. KINDS OF WALLS.

It is thus seen that cellulose in its various modifications constitutes the greater proportion of the cell wall. The cellulose making up the cotton fiber may be said to be the typical cellulose, and is known as "cotton cellulose." It is soluble in copper ammonium sulphate solution; is colored blue with chlor-zinc-iodide solution or iodine and sulphuric acid, and is stained by acid

phenolic dyes, as alizarin, if previously treated with basic mordants, as basic salts of aluminum, etc.

According to their origin in the plant, or their behavior toward reagents, the cellulose walls may be divided into the following groups: (1) Lignocellulose walls; (2) protective cellulose walls; (3) reserve cellulose walls; (4) mucilage cellulose walls, and (5) mineral cellulose walls.

(1) **Lignocellulose walls** are composed of true cellulose and a non-cellulose (the so-called lignin or lignone), these constituting the woody (so-called lignified) por tion of plants and, in some instances, also the bast portion of the bark. The lignocelluloses are colored yellow with chlor-zinc-iodide, or iodine and sulphuric acid. On account of their containing, in some instances, furfurol, coniferin, vanillin, cinnamic aldehyde, benzaldehyde and other aldehydic substances, they give definite color-reactions, particularly with the aniline stains, as fuchsin, safranin, gentian violet, aniline blue, methylene blue, etc.

A 2 per cent. phloroglucin solution, used in conjunction with hydrochloric acid, gives a reddish-violet color with the lignocelluloses, although there are some celluloses of this class which do not respond to this test, as the bast fibers of linum; while in other plants phloroglucin may occur as a constituent of the cells.

Aniline hydrochloride with hydrochloric acid and aniline sulphate with sulphuric acid produce a golden yellow color in cell walls containing lignocelluloses.

(2) **Protective cellulose walls** are composed of mixtures of lignocellulose with oils and waxes, and frequently contain in addition tannin, vanillin and other compounds. In the cuticle or epidermis of leaves and green stems, the cellulose is associated with a fatty compound known as cutin or cutose, while in the cork

of stems and roots it is combined with suberin or suberose. This class of celluloses is distinguished from cotton cellulose and lignocellulose by being insoluble in sulphuric acid.

(3) **Reserve cellulose walls** are those found in various seeds, as in coffee, date, nux vomica, etc. They behave toward reagents much like the true celluloses.

(4) **Mucilage cellulose walls** consist of cellulose and mucilage and are found in all parts of the plant, and in the case of seeds are associated with the protective celluloses. They dissolve or swell in water, are colored blue or yellowish with iodine, and are stained with alcoholic or glycerin solutions of methylene blue.

(5) **Mineral cellulose walls** are composed of cellulose and various inorganic substances, as silica, calcium oxalate or calcium carbonate. These are more commonly found in the cell wall of the lower plants, as algæ, fungi and Equisetaceæ. Calcium carbonate also occurs in the cystoliths of the various genera of the Urticaceæ.

From what has just been said of the chemical composition and structure of the cell wall, it is seen that it consists of lamellæ or layers of different substances, and in no case does it consist of but a single substance; but for convenience we speak of a wall as consisting of cellulose, lignin, or suberin, meaning thereby that the wall gives characteristic reactions for these substances.

In some cells, as in lignified cells, the lamellæ are quite apparent, whereas, in other cases, the use of reagents, as chromic acid, or chlor-zinc-iodide, is necessary to bring out this structure. The layering which is observed in transverse sections of the cell wall is spoken of as **stratification** of the wall, whereas, the layering observed in longitudinal or tangential sections is referred to as **striation** of the wall.

III. THICKENING OR MARKING OF WALLS.

In the formation of the cell wall each cell appears to work in unison with its neighbors for the building up of the plant. The thickening of the walls of the cell is primarily for the purpose of strengthening the walls, but if the walls were uniformly thickened, osmosis, or the transferral of cell sap from one cell to another, would be hindered. Thus, we find that the contiguous walls of the cells are thickened correspondingly at definite places opposite each other, leaving pores or canals which permit rapid osmosis between the thickened portions. The pores thus formed are known as simple pores, and in surface view are somewhat elliptical or circular in outline, and may be mistaken for some of the cell-contents. These thickenings assume a number of forms, which are quite characteristic for the plants in which they are found. They may have the form of transverse or oblique rings, longitudinal spirals, or they may be ladder-like or reticulated in appearance. In other instances the thickening of the wall is quite complex, as in the wood of the pines and other Coniferæ. The thickening, or sculpturing, as it is sometimes called, may not only occur on the inner surface of the wall, when it is spoken of as **centripetal**, but may also take place on the outer surface, when it is known as **centrifugal**; as examples of the latter, may be mentioned the spores of lycopodium and the pollen grains of the Compositæ.

E. FORMS OF CELLS.

Upon examining sections of various portions of the plant, it is observed that not only the cell-contents and cell wall vary in composition, but that the cells themselves are of different forms, depending more or less upon their function; they may be classified, for

convenience of study, as follows: (1) parenchyma cells, (2) mechanical cells, (3) conducting cells and (4) protection cells.

I. PARENCHYMA.

Under the head of parenchyma are included those cells which are nearly isodiametric and thin-walled, the walls consisting of cellulose lamellæ. They may contain both organized and unorganized cell-contents. According to the function and nature of contents, three kinds of parenchyma cells are recognized: (*a*) **Chlorophyl-parenchyma** or assimilation parenchyma, which is rich in chloroplastids and occurs in leaves and all green parts of the plant. (*b*) **Reserve parenchyma** occurs in seeds, roots, rhizomes, etc., and contains starch, aleurone grains, fixed oils and other reserve materials. The parenchyma in stems and leaves of various of the orchids, as well as that of plants of arid regions, which store water, may be included in this group. (*c*) **Conducting parenchyma** assists in the transferral of food from one part of the plant to another.

Besides these forms of parenchyma there are some special kinds which may be mentioned, as the somewhat branching cells in leaves, and in the stems of various marsh plants, as in species of *Juncus* and *Pontederia.* In calamus, large intercellular spaces are formed, and these may be mistaken for the cells themselves.

II. MECHANICAL CELLS.

Mechanical cells include all those cells which serve to keep the various parts of the plant in their proper positions one with reference to the other, and which enable it to withstand undue strain and pressure. There are two principal forms of mechanical cells, namely, collenchymatous and sclerenchymatous.

The Collenchyma cells are long cells (occasionally 2 mm. long) which are thickened at the corners or intercellular spaces. The walls consist of cellulose, or a modification of it, known as collenchym, and have a silvery or grayish-blue luster. Besides the organized contents these cells occasionally contain starch. They are found directly beneath the epidermis of herbaceous stems, petioles, and the midrib of various leaves, and are particularly noticeable at the angles of all stems that are ribbed or angled in transverse section.

Sclerenchyma cells include all of those cells which have more or less uniformly thickened walls consisting of lignocellulose and permeated by simple or branching pores. They have a thin layer of protoplasm and relatively large vacuoles, which contain tannin or tannin-like masses, and occasionally calcium oxalate crystals or starch, and upon the death of the cell the lumen contains air. Two kinds of sclerenchyma are recognized: one in which the cells are more or less isodiametric, known as **stone cells** (short sclerenchyma or *sclereïden*); and another in which the cells are elongated, being from ·5 to 2 mm. long, as a rule, known as **sclerenchyma fibers** (or long sclerenchyma). Of these, two kinds are distinguished, chiefly according to their position in the plant, namely, bast fibers and wood fibers (or libriform). Seldom are the wood and bast fibers in the same plant uniform in structure and composition, as in glycyrrhiza and althæa. On the other hand, they are with difficulty distinguished in monocotyledenous roots, and the term sclerenchymatous is here best employed. In the study of powdered drugs the term sclerenchymatous fiber may be employed with advantage when speaking of wood and bast fibers, as in this condition they are not readily distinguishable.

Stone cells are usually polygonal, or more or less

irregular in outline, sometimes even branching. The walls are distinctly lamellated, and they give the characteristic reaction for lignocellulose with phloroglucin and aniline sulphate; occasionally, however, one or more of the sides remain unthickened. The pores are elliptical or circular on surface view.

Bast fibers are sclerenchymatous fibers which are associated with sieve cells, and which may, or may not, give a pronounced reaction for lignocellulose with phloroglucin and aniline sulphate. In transverse section they are more or less round or polygonal, depending upon whether they are isolated or in groups. They vary in diameter and length, and also in the thickness of the walls; while most bast fibers are between 1 and 2 mm. in length, they may be more than 200 mm. in length, as in *Boehmeria nivea.* The ends may be more or less obtuse, or drawn out to a fine point; occasionally they are somewhat branched. The pores in surface view are narrow elliptical and are arranged according to a left-handed spiral. The spiral arrangement of the component substances of the wall is supposed to give strength to the fibers and, according to Schwendener, they will sustain a weight nearly equivalent to that sustained by wrought-iron and steel.

Bast fibers may be isolated by the use of Schulze's macerating fluid, which is prepared by dissolving a few crystals of potassium chlorate in nitric acid and moderately heating the solution containing the material either on a slide or in a test tube.

Wood fibers are sclerenchymatous fibers which are associated with ducts, and which usually give a more or less distinct reaction for lignocellulose. They occur more frequently than bast fibers (gentian being one of the few drugs in which they are wanting) but seldom

attain the length of the latter. They are not infrequently branched at the ends, and besides a thin protoplasmic layer, they usually have no other contents than water and air. They usually have the yellowish color, characteristic of stone cells, and also a similar lamellation and refraction of the wall.

III. CONDUCTING CELLS.

Conducting cells include those cells which are chiefly concerned in the transferral of either crude or assimilable food materials. The more or less crude inorganic materials are carried from the root through the woody portion of the stem to the leaves, and from the leaves the products of CO_2 assimilation, as well as other plastic substances, are distributed through some of the tissues of the bark to other parts of the plant. The tissues or elements of the wood which conduct food materials are of several forms and include tracheæ or ducts, tracheids and conducting parenchyma; and the elements of the bark which transport the assimilable materials, comprise the sieve and conducting parenchyma, although there are other elements which sometimes assist these two groups of cells in the work of conduction.

The **tracheæ** or **ducts** are formed by the disintegration and removal of the transverse walls between certain superimposed cells, forming an elongated cell or tube, which occasionally retains some of the transverse walls. The longitudinal walls are relatively thin and consist of lignocellulose, giving more or less pronounced reactions with phloroglucin and aniline sulphate.

The thickenings of the longitudinal walls of ducts are quite characteristic, several forms being distinguished: Those having the thickenings in the form of

horizontal or oblique rings are known as **annular ducts**; those having the thickenings in the form of spirals, which usually run from right to left, are known as **spiral ducts**; those having the thickenings in the form of a reticulation are known as **reticulated ducts**, and those with horizontal, disconnected thickenings which occur in parallel lines, resembling a flight of steps, are known as **scalariform ducts.**

In those ducts in which but few of the transverse walls are obliterated, the walls aie marked by both simple and bordered pores (for a description of the latter, see Tracheids).

Ducts contain water, water-vapor and air; in some cases they contain sugar, tannin, mucilage or resin.

The **tracheids** are intermediate in character between ducts and wood fibers, resembling the former in possessing bordered pores and scalariform thickenings; and the latter in being true cells, which are usually elongated and quite thick-walled, the walls giving distinct reactions for lignocellulose with phloroglucin and aniline sulphate.

One of the chief characteristics of tracheids are the **bordered pores.** These differ from simple pores in that the wall surrounding the pore forms a dome-shaped or blister-like protrusion into the cell. On surface view the pores are either circular or elliptical in outline, the dome being circular or, if the pores are numerous and arranged close together, more or less polygonal.

The number and distribution of bordered pores in the Coniferæ are quite characteristic for some of the genera, and may be studied in any of the pines, the pores being most numerous along the radial walls.

The **sieve** (sieve tubes) is distinguished from the other conducting elements, in that the walls are thin and

are composed of cellulose. It consists of superimposed elongated cells, the transverse walls of which possess numerous pores which are supposed to be in the nature of openings, permitting of the direct passage of the contents from one cell to the other. This transverse wall, which may be either horizontal or oblique, is known as the **sieve plate**, and the thin places, as pores of the sieve. The sieve plates are sometimes also formed in the longitudinal walls. On the sieve plates of plants, the activities of which are suspended during the winter, there is formed on either side of the plate a layer of a colorless, mucilaginous substance, known as callus, which has somewhat the appearance of collenchyma, but is colored brownish by chlor-zinc-iodide.

The sieve cells contain an albuminous substance somewhat resembling protoplasm; in some instances starch grains have also been found.

When the activities of the sieve tubes have ceased, they become altered in shape, owing to the activities connected with growth in neighboring cells, as well as in other parts of the plant, and are then known as obliterated sieve. In the drying of plants a similar alteration is produced, and for this reason the sieve of vegetable drugs is of this character.

IV. PROTECTING CELLS.

Protecting cells include those cells which are located on the outer parts of the plant. The function of these cells is to lessen the rate of transpiration, or the giving off of water; to furnish protection against changes of temperature, and to protect the inner tissues against the attack of insects; they also have a mechanical function.

Depending principally upon their composition, these

cells may be divided into two classes, namely, epidermal cells and cork cells.

The **epidermal cells** constitute the outermost layer of the plant. They contain the organized cell-contents, the plastids in some instances being wanting; in some instances they also contain dissolved coloring principles; and on account of the relatively large amount of water which they contain, they are classed among the important water-reservoirs of the plant.

The walls are principally characterized by one or more lamellæ of cutin, these uniting to form a continuous outer wall; usually cutin is present only in the outer wall. The cutin, is not infrequently associated with wax, this constituting the bloom of fruits; less frequently such inorganic substances as calcium carbonate, calcium oxalate and silica are present, and not infrequently mucilage is present, as in the walls of seeds.

On surface view the form of these cells varies from nearly isodiametric to oblong; they may also be polygonal or branched. In transverse section their radial diameter is much the shorter. In some instances the inner and side walls are considerably thickened, as in the seeds of a number of the Solanaceæ.

The epidermal layer may not only consist of a single layer of cells, but may have additional layers underneath forming the **hypodermis**, as in the upper surface of the leaves of species of *Ficus;* in some instances the hypodermis undergoes a mucilage modification, as in the leaves of buchu.

Plant Hairs.—The epidermal cells are sometimes specially modified centrifugally, giving rise to papillæ, to which the velvety appearance of the petals of flowers is due; in other cases this modification is in the form of hairs. These may be unicellular or multicellular, and in addition the latter may be secreting or non-

secreting. Secreting hairs possess a head-like apex, consisting of one or more cells, and they secrete oil, mucilage and other substances. (For the various forms of these hairs, see plates).

Stomata.—Epidermal cells have still another modification in the development of a special apparatus for regulating transpiration, in particular: From a single epidermal cell two cells are formed, which are known as **guard cells**, the whole being known as a stoma. The adjoining walls of the guard cells are alike in transverse section, but vary in shape in different plants; they are more or less elastic, and when the cells are turgescent, as when there is an abundance of water and root pressure is strongest, the contiguous radial walls of the guard cells recede from each other, forming an opening between the cells, thus permitting the easy passage of both air and water.

The guard cells may be slightly raised above or sunk below the surrounding epidermal cells, the number of the latter being characteristic for certain plants.

In surface view the stomata may be elliptical or circular. They occur in the largest numbers on the blades of foliage leaves, being more numerous on the under surface, except in aquatic plants where they occur only upon the upper surface.

Water Pores.—Near the margin of the leaf and directly over the ends of conducting cells, not infrequently occur stomata, in which the function of opening and closing is wanting, and which contain in the cavity below the opening water and not air, as in true stomata. These are known as water pores, and they give off water in the liquid form, the drops being visible on the edges of the leaves of nasturtiums, fuchsias, roses, etc., at certain times.

ɔRMS OF PLANT CELLS.

CLASS.	PARENCHYMA.	MECHANICAL CELLS.			CONDUCTING CELLS.			PROTECTING CELLS.	
Name	Parenchyma	Collenchyma	Stone cells	Scleren-chyma fibers	Ducts or Tracheæ	Tracheids	Sieve	Epidermis	Cork
Occurrence	Associated with any of the other cells	Usually beneath the epidermis	Usually in fruits, seeds and the bark	Forming a part of the fibro-vascular tissue	Forming a part of the xylem	Forming a part of the xylem, especially in the Coniferæ	Forming a part of the phloem	The outer layer of herbaceous plants	At or near the surface of older roots and stems
Form	Nearly isodiametric	Elongated	Nearly isodiametric	Elongated	Elongated	Elongated	Elongated	Isodiametric, polygonal or brauched	isodiametric or polygonal
Cell-contents	Organized aud unorganized	Organized and starch	Organized, starch, tannin, calcium oxalate	Organized, tannin	Water, air, sugars, tannin, mucilage, resin	Water, air, sugars or tannin, mucilage, resin	Albuminous substances, occasionally starch	Organized, water	Organized, tannin or calcium oxalate
Composition of cell wall	Cellulose	Collenchym	Ligno-cellulose	Ligno-cellulose	Ligno-cellulose	Ligno-cellulose	Cellulose	Cutin, wax, mucilage, calcium oxalate, calcium carbonate or silica	Suberin
Markings of wall	Frequently with simple pores	Frequently with simple pores	Simple or branching pores	Narrow elliptical oblique pores	Annular, spiral or reticulated thickenings, simple or bordered pores	Bordered pores or scalariform thickenings	Simple pores, connecting sievc cells	No pores, except in the parts of the flower	No pores

Cork cells replace the epidermal cells of roots and stems that persist year after year. They differ from the epidermal cells in that the walls are uniformly thickened and on surface view are polygonal in shape. The walls consist of suberin, a substance allied to cutin; in some instances they also contain ligno-cellulose, forming cork-stone cells, as in asclepias. The young cells may contain a thin layer of protoplasm and a nucleus; they usually also contain brownish tannin, or tannin-like compounds, and occasionally crystals of cerin, or calcium oxalate.

Cork not only occurs as a secondary protective layer, but may also arise in other parts of the plant as a result of injury, as in leaves, fruits, stems and tubers. It also arises as a result of the disarticulation of the leaf in autumn.

Lenticels may be described as biconvex fissures in the cork which permit of the easy passage of air through the intercellular spaces of the rather loosely arranged cells lying beneath them. They usually arise as the product of a meristem situated beneath the stomata of the epidermis, the stomata being replaced by them in the development of cork. Several types of lenticels are distinguished. They are quite characteristic and prominent in a number of barks, as those of species of *Betula*, *Prunus*, *Rhamnus*, etc.

LATICIFEROUS TISSUE.

Laticiferous or milk tissue occurs in all those plants which emit a milk-juice on being cut or otherwise wounded. The juice may be colorless, as in the oleander; whitish, as in the Asclepiadaceæ and Apocynaceæ; or yellowish or orange, as in the Papaveraceæ. It contains caoutchouc, oils, resins, mucilage and starch, calcium oxalate and alkaloids as well. The walls are rela-

tively thin and consist chiefly of cellulose. The tissue consists either of single cells of indefinite length, as in the Asclepiadaceæ, or it may consist of a more or less branching net-work formed by the anastomosing of a number of cells, as in *Taraxacum.* It is distributed or associated with the sieve in nearly all parts of the plant; in the earlier stages the cells contain organized cell-contents which later disappear or are with difficulty distinguished from the other substances already enumerated as present in the milk-juice.

SECRETION CELLS OR RESERVOIRS.

In *Sanguinaria* there occurs a rudimentary laticiferous tissue, most of the juice being contained, however, in special parenchymatous cells, which may be more or less isolated or arranged in irregular longitudinal rows. Cells of this character are known as secretion cells and usually contain oil, resin, tannin, calcium oxalate, mucilage, etc., instead of substances forming an emulsion or milk-juice; these cells are distributed in all parts of the plant, including the epidermal cells of secretion hairs. The walls usually consist of cellulose but may have lamellæ of cutin and suberin, the latter being found particularly in the oil-secretion cells of rhizomes, roots, barks and fruits.

In some instances mucilage cells containing raphides occur in longitudinal rows resembling the secretion cells of *Sanguinaria;* in some of the ferns, the barks of elder and locust, and leaves of the Crassulaceæ, the tannin-cells are very much elongated, resembling the simple laticiferous cells in the Asclepiadaceæ.

Oils, resin, mucilage, gum-resins and allied products occur quite frequently in special reservoirs or cavities formed as already described in the footnote on page 33.

CHAPTER II: THE VEGETATIVE AND REPRODUCTIVE PARTS OF THE PLANT.

In the preceding chapter the nature and structure, together with the modifications of form of the units composing plants, namely, the cells, have been considered. These units are grouped to form tissues[1], and these are arranged in the higher plants to form more or less distinct and differentiated parts, which, according to their structure and function, may be divided into two distinct groups: (1) The vegetative and (2) the reproductive. The vegetative parts include the root, stem and leaf, and are principally instrumental in carrying on the work of absorption, conduction and assimilation of food material. The reproductive parts are included in the flower, from which are finally developed fruit and seeds.

A. THE VEGETATIVE PARTS.

I. THE ROOT.

Inasmuch as the reproductive parts of the plant are considered to be modifications of stem and leaf, the vegetative parts will be considered first. To properly understand the nature of these, it is desirable to begin with the germination of the seed. The

[1] The term tissue may be used in a restricted sense to include aggregates of cells which are similar in origin, shape and function; or it may be employed to designate groups of cells having different origin and shape, but which perform a similar function, as conducting tissue, which may be composed of ducts, wood parenchyma and wood fibers; or it may be applied to still larger aggregates of cells which are different in shape and function but of similar origin, as fibrovascular tissue, which is composed of the conducting and mechanical tissues formed from the cambium.

seed represents the offspring of the plant and contains an embryonic plant consisting of three more or less distinct parts, which are more easily differentiated after germination.

If we take the seed of a pea or bean or other flowering plant, and surround it with conditions favorable to its germination and growth, it is soon observed that one part of the young plant invariably grows downward, unless there is some obstruction, and this is known as the root. Connected with this is another part which usually grows in an opposite direction, and this is known as the stem. Upon the latter are developed parts called leaves. The first leaves formed are known as seed leaves, and if they are two in number the plant is known as a **dicotyledon**, whereas if there is only one seed leaf, the plant is called a **monocotyledon**.

The root or descending axis of the plant is popularly supposed to grow downward, in order to avoid the light. The roots of plants grown in hanging baskets, however, naturally emerge into the light, and then continue their downward growth. On the other hand, it is supposed by many (as a result of Knight's experiments) that the root grows downward by reason of the influence of gravity. In addition it may be said that the principal functions of the root, namely, those of preparing and absorbing inorganic food materials, and of fixing the plant to the soil, determine in a measure the direction of its growth. The tendency of the root to grow downward is a characteristic which distinguishes it from other parts of the plant and is known as **positive geotropism**.

If we take a germinating plant and mark the root lengthwise, by means of a fine pen and India-ink, into ten equal divisions, beginning at the apex, and place

the plant in a moist chamber, it will be found in the course of one or two days that the marks between 1 and 5 have become much farther apart, and that the growth in this region is about three times that between 5 and 10. This experiment indicates that the growth of the root takes place at or near the apex, this region being known as the **point of growth**, or point of vegetation.

Upon examining the tip of a very young root by means of the microscope, it will be seen that the growing point is protected by a group of thin-walled parenchyma cells, and these constitute the **root cap.** The root cap varies in length, being most apparent in the roots of aquatic plants, or plants producing aerial roots.

Just above the root cap there is developed a narrow zone of delicate hairs, which are usually simple and filled with protoplasm. These are known as **root hairs** and their function is twofold: (1) They secrete an acid which renders the inorganic substances of the earth soluble, and (2) they absorb these dissolved substances for the nourishment of the plant.

When the germinating root persists, it is called the main, tap or **primary root**; when it divides into a number of similar branches it is known as a **multiple primary root**, as in dahlia. Branches may arise in addition.

There are some plants which complete their cycle of growth in one year, and such plants are spoken of as **Annuals.** Other plants produce only roots, stems and leaves the first year. The roots are large and fleshy and contain large quantities of nutritive matter, which is stored for the use of the plant the following year, when it produces fruit and thus completes its cycle of growth. Plants of this class are known as **Biennials,** and the roots as root-tubers or tuberous roots. Plants

which persist year after year are known as **Perennials.** Sometimes, as in temperate climates, the roots only are perennial, as in *Phytolacca decandra,* when the plant is spoken of as a **perennial herb.**

(*a*) MODIFIED ROOTS.

Roots which arise from the joints of the stem or other parts of the plant are known as secondary or adventitious roots. These include the aerial roots of the banyan tree, which are for the purpose of support; the roots of the ivy, which are both for support and climbing, and the roots of Indian corn, which serve both for support and the absorption of nourishment. Under this head may also be included the aerial roots of orchids and the root-like structures, called **haustoria,** of parasites (as of mistletoe), and saprophytes (as dodder), which penetrate the tissues of their host plants.

(*b*) THE STRUCTURE OF THE ROOT.

Primary Structure.—If we make a transverse section of the root of a germinating plant, through the portion developing root hairs, the following arrangement of tissues is observed: (1) An **epidermal** layer with root hairs; (2) a **hypodermis** of a few layers of cells; (3) a **cortex** made up of a number of layers of parenchyma cells; (4) a single layer of more or less lignified cells, known as the **endodermis**; (5) a **central cylinder** consisting of parenchyma and alternating groups of ducts and sieve, the number[1] of which varies and is more or less constant for certain genera. This arrangement constitutes what is known as the primary structure of the roots, and is essentially the same in both monocotyledons and dicotyledons.

[1] The terms monarch, diarch, triarch, tetrarch, polyarch, etc., are used to designate the number of plates or groups of ducts, there being usually a larger number of groups in the roots of monocotyledonous plants than in those of dicotyledons.

Secondary Structure.—While monocotyledonous roots grow in length, they do not grow perceptibly in thickness, so that, for instance, a sarsaparilla root, which may be nearly three meters in length, will show but little variation in thickness throughout its entire length. Dicotyledonous roots, however, soon begin to grow in thickness, as well as in length, the latter being less marked than in the monocotyledons.

In monocotyledons the primary structure of the root is for the most part retained, the only change being an increase in thickness of the walls of some of the cells. On the other hand, the increase in diameter of dicotyledonous roots is accompanied by marked changes in the primary structure. Some of the cells at the periphery of the ducts and upon the inside of the sieve become meristematic, forming a continuous zone or ring, known as the **cambium.** On the outside of the cambium not only sieve cells but bast fibers and bast parenchyma may be developed, the whole constituting the **phloem.** Besides the ducts upon the inside of the cambium tracheids, wood fibers and wood parenchyma may develop, forming the **xylem.** The xylem and phloem, together with the intervening cambium, form a group constituting what is known as a **fibrovascular bundle.** Another kind of cells, which are nearly isodiametric or radially elongated, also arise from the cambium and form radial rows, which are known as the **medullary rays.** The latter separate the fibrovascular bundles, and the number of cells, both as regards the width and depth of the rows, is characteristic for certain genera.

At the same time that the cambium is developing xylem and phloem, another meristem, known as the **phellogen,** arises within the endodermis, which produces upon the inside parenchyma, known as the **secondary**

cortex, and upon the outside, cork. This stage in the growth of the root marks the beginning of the development of secondary structures. At the periphery there is a disintegration of the cells of the endodermis, cortex and epidermis of the primary root, these being replaced by the secondary structures as shown in the illustrations. A transverse section of a root showing fully developed secondary structures is also shown.

The characteristics distinguishing the primary and secondary structures of dicotyledonous roots may be summarized as follows:

PRIMARY STRUCTURE.

Epidermis and root hairs.
Hypodermis.
Primary cortex consisting of parenchyma.
Endodermis.
Phloem and xylem in alternating radial rows, constituting a radial fibrovascular bundle.

SECONDARY STRUCTURE.

Cork cells.
Phellogen.
Secondary cortex consisting of parenchyma.
Phloem, Cambium, and Xylem, $\left\{ \begin{array}{l} \text{arranged in concentric layers, forming} \\ \text{concentric fibrovascular bundles.} \end{array} \right.$
Medullary rays separating the fibrovascular bundles.

Sometimes, as in glycyrrhiza and valerian, a number of parenchyma cells are found in the center of the root, these constituting the **pith** or medulla; but they are usually wanting in dicotyledonous roots.

Wood and bark are terms used to distinguish those portions of the root or stem separated by the cambium; all that portion inside of the cambium, including xylem, medullary rays and pith, being known as the **wood**. The **bark** includes the phloem, the medullary rays outside of the cambium, as well as products of the phellogen.

The following diagram of the secondary structure of a dicotyledonous root may be of assistance in understanding the origin and relation of the tissues comprising it:

- Cambium produces
  - Wood made up of
    - Pith, which may be wanting.
    - Xylem
      - Composed of ducts, wood parenchyma and wood fibers; or tracheids may replace these, or be associated with them. These are arranged in groups forming radial rows which are separated by medullary rays.
  - Bark made up of
    - Phloem
      - Consisting of sieve and bast parenchyma; bast fibers may also be present These are arranged in groups and form radial rows which are separated by medullary rays.
    - Phellogen, producing parenchyma and cork.

The **root branches** arise as the product of a meristem, known as the **pericambium**, situated inside of the endodermis. The tissues forming the branches are directly connected with the fibrovascular tissues of the root and protrude through the overlying tissues without having any connection with them. The structure of the branches thus formed corresponds to the primary structure of the roots, and in the case of dicotyledonous roots may also subsequently develop a secondary structure.

Contraction of the roots is observed in both monocotyledons and dicotyledons, it being most apparent in the former, as in veratrum viride. The uneven or corkscrew-like appearance is due to this contraction, which arises as follows: Some of the longitudinally elongated cells beneath the epidermis absorb large quantities of water, which causes them to assume a spherical form (as the cells of a potato are altered on boiling),

the result being a longitudinal contraction of the root at this point. In this way the plant is fastened more securely to the earth, and at the end of the season's growth the apical buds of plants, with upright rhizomes, as of *Veratrum viride*, *Dracontium*, etc., are drawn into the earth and thus protected during the winter.

Abnormal Structures of Roots.—It is frequently difficult to recognize the type-structure of dicotyledonous roots, owing to the development of anomalous and abnormal secondary structures. Sclerenchymatous fibers, while present in glycyrrhiza and althæa, are not infrequently wanting. Wood fibers may be sparingly developed, as in belladonna, or even wanting, as in gentian. In other cases the medullary rays are abnormal, being replaced in calumba by wood parenchyma, and in ipecac and taraxacum by sclerenchymatous cells In asclepias and calumba a layer of stone cells occurs near the periphery; in gentian, sieve cells develop in the xylem; in senega the xylem is not uniformly developed, and in still other cases, as in jalap, pareira and phytolacca, successive cambiums develop, producing a concentric series of fibrovascular bundles.

II. THE STEM.

The stem, or ascending axis of the plant, grows in a direction opposite to that of the root, seeking the light and air. The tendency of the stem to grow upward is characteristic of the majority of plants, and is spoken of as **negative geotropism.** The growing point of the stem is at the apex, and it is protected by the embryonic leaves.

Stems are further characterized by bearing leaves, or modifications of them. The leaves occur at regular intervals in the same species, and that portion of the

stem from which they arise is spoken of as **a node,** while the intervening portion is called an **internode.**

Stem branches normally arise in the axils of the leaves, first appearing as little protuberances on the stem. Their origin differs from that of the root branches, in that they arise as the product of meristems developed just beneath the epidermis. The branches, like the main stem, manifest negative geotropism, possess a growing point at the apex, covered with embryonic leaves, and consist of nodes and internodes. They may be regarded as a means of developing the plant in a lateral direction.

Buds may be regarded as embryonic stems or branches. The bud at the end of a stem or branch is known as an **apical,** or **terminal bud**; and those situated in the axils of the leaves, as **axillary buds.** In some cases they are protected by scales, as in hickory, when they are known as **scaly buds**; while buds which are not thus protected, are called **naked buds.** They are further distinguished as leaf, flower, and mixed buds, according as they contain or develop leaves, or flowers, or both.

(*a*) MODIFIED STEMS.

The stem, like the root, does not always possess the typical characteristics given. While most stems attain a more or less erect position, there are others which bend over to one side, or lie prostrate on the ground, and in some cases produce roots from the nodes, as in *Mentha piperita.*

The stems of a number of plants grow underground and are known as **Rhizomes** or **root-stocks**; from the upper portion of the nodes overground branches arise, and from the lower surface, roots. While most rhizomes are perceptibly thickened, and

more or less fleshy when fresh, as of sanguinaria, in other instances they are of the ordinary thickness of the overground stem.

There are some rhizomes that are excessively thickened, as in the common white potato, and these are called **tubers.**[1] The eyes represent the nodes, from which the leaves and branches arise. Tubers should not be confounded with tuberous roots, as those of the sweet potato and jalap, possessing as they do the morphological characteristics of roots.

Instead of the node, or internode, or both, becoming excessively thickened, they may be reduced in size and crowded upon each other, the leaves at the same time becoming thickened and filled with nutriment. Such a modified stem and leaves, as in the onion, is called a **bulb.** Bulbs are sometimes produced in the axils of the leaves of overground stems, as in some lilies, and are then called bulblets. Bulbs can thus be looked upon as being in the nature of fleshy buds.

A **corm** is intermediate between a true tuber and a bulb; it is more in the nature of a thickened internode, being surrounded in some cases by thin membranous scales, as in crocus and colchicum.

Branches are not infrequently modified to hard, pointed and spiny structures, as in the Japanese quince, when they are spoken of as **thorns.** Leaves and even flowers may arise upon thorns, which shows that they are modified branches.

A number of plants ascend into the air on other plants, or other objects which serve as supports, either

[1] Swellings on stems or roots may be due to a number of agencies, viz.: Parasitism or saprophytism of other plants, as mistletoe and dodder; the presence of fungi, as on some Coniferæ, notably pines; the action of insects producing so-called galls on certain species of oak, hickory, willow, etc.

by attaching themselves to them or by crawling around them, when they are distinguished as twiners and climbers. **Twiners** ascend by a special circumnutating movement of the stem, as in the morning glory; **climbers,** however, ascend by means of special structures, as the aerial roots of the ivy, and are termed **root climbers**; or they may climb by means of leaves, as in the clematis, and these are known as **leaf climbers**; still others climb by means of tendrils, as in the grape, and these are known as **tendril climbers.** These tendrils, which are thread-like modifications of the stem, are in some cases provided with disk-like attachments for holding the plant in position, as in the Virginia creeper.

Stems vary furthermore in size and form. While most stems are more or less cylindrical or terete, other forms also occur, as the flattened stems in the Cactaceæ; triangular in the Juncaceæ, and quadrangular, in the Labiatæ and Scrophulariaceæ.

(*b*) THE STRUCTURE OF THE STEM.

If we make a transverse section of a **dicotyledonous stem** a little below the growing point, we observe a differentiation of the tissues, as follows, this arrangement representing the primary structure: (1) The epidermis without root hairs; (2) a hypodermis; (3) a cortex; (4) an endodermis; (5) collateral fibrovascular bundles separated by primary medullary rays, and (6) a pith in the center. The essential difference between the primary structures of the stems of dicotyledons and monocotyledons, is that in the latter the fibrovascular bundle is of the concentric type, the medullary rays being wanting.

On comparing the primary structure of the root with that of the stem, the following essential differences are observed:

ROOT.	STEM.
Epidermis with root hairs.	Epidermis without root hairs.
Cortical parenchyma without chloroplastids.	Cortical parenchyma with chloroplastids.
Fibrovascular bundles, radial, more numerous in monocotyledons than in dicotyledons.	Fibrovascular bundles, collateral (dicotyledon), or concentric (monocotyledon).
Pith usually wanting.	Pith always present.

The development of the **secondary structure in dicotyledonous stems** is quite simple compared to that of the root. The cambium develops into a continuous ring, producing xylem within and phloem without. A phellogen arises within the endodermis, and the cork replaces it and the overlying primary tissues.

The arrangement of the tissues in the primary and secondary structures of dicotyledonous stems may be compared as follows:

PRIMARY STRUCTURE.	SECONDARY STRUCTURE.
Epidermis.	Cork.
Hypodermis.	Phellogen.
Primary cortex.	Secondary cortex.
Endodermis.	Fibrovascular bundles, radial, numerous and separated by secondary medullary rays.
Fibrovascular bundles, radial and few.	
Pith.	Pith cells frequently disintegrated.

Monocotyledonous stems, like monocotyledonous roots, usually grow in length, without much increase in thickness, except in certain cases, as in rhizomes and palm stems, and retain for the most part the primary structure. Where increase in thickness of the stem takes place, the cells of the endodermis are altered in shape, and the walls of the hypodermal cells become thickened with lignocellulose and suberin.

The stem as well as the root develops abnormal and anomalous structures, although they are not of

sufficient importance to warrant consideration in this connection.

III. THE LEAF.

(a) SIMPLE LEAVES.

The leaf is a lateral development on the stem and branches, in the axil of which a bud occurs. Leaves originate, like the branches, as the product of a meristem developed just beneath the epidermis. A simple leaf consists of a **lamina** or blade, which is usually membranous and of a green color, and a **petiole** or stalk, which, however, may be wanting when the leaf is said to be **sessile.** Leaves may also possess a pair of leaf-like structures at the base, which are known as **stipules.** While the lamina of the leaf appears to assume a more or less horizontal position, it usually inclines at such an angle as to receive the greatest amount of diffused daylight. Wiesner has shown, for instance, that when plants are so situated that they receive direct sunlight only for a time in the morning, and diffused daylight during the rest of the day, the position of the upper surface is perpendicular to the incident rays of daylight, and not to that of the rays of the morning sun. This phenomenon may be studied in the house geranium and other window plants. In endeavoring to explain this behavior of the leaves, Frank assumes it to be due to a kind of heliotropic irritability peculiar to dorsiventral[1] organs, and terms it **transverse heliotropism.**

The stem, as well as the petiole or stalk of the leaf, is also influenced by the light, and is said to manifest

[1] Dorsiventral is a term applied to any foliaceous part of the plant in which two surfaces are distinguished, each possessing a difference in structure, the one surface being known as the dorsal and corresponding to the lower surface, as in the leaf, and the other as the ventral and corresponding to the upper surface. The

"positive heliotropism." Those parts of plants that turn away from the light, as the aerial roots of the ivy, are said to possess "negative heliotropism."

(b) FUNCTIONS OF THE LEAF.

The principal functions of the leaf are CO_2 assimilation, transpiration and respiration. **CO_2 assimilation** is carried on, as we have already seen, by the chloraplastids, oxygen being formed as a by-product; **transpiration** is the giving off of water (through water-pores), or watery vapor (through the stomata), which has been absorbed by the root hairs and transported through the tissues of the root, stem and leaf; the process of breathing, or **respiration**, consists in the taking in of oxygen and giving off of carbon dioxide. These several functions are, however, not confined to the leaf alone, but are carried on by all the green portions of the plant.

(c) VENATION OF LEAVES.

A more or less close examination of the leaf shows it to possess a number of distinct markings, which are called **veins** or nerves. The vein traversing the center of the leaf from base to apex is usually more prominent than the others, and is called the **midrib**; if we compare the venation of the leaf of lily of the valley, or *Veratrum viride*, with that of the oak or pansy, it is observed that in the former the veins all run parallel to the midrib, whereas in the latter the veins originate in the midrib, and repeatedly branch and anastomose with each other, forming a network. The former are known

use of the terms dorsal and ventral in place of upper and lower is particularly desirable in describing the surfaces of erect or ascending leaves, as of Iris; or leaves in which the petiole is twisted so that the surfaces are either vertical, as in the phyllodia of Australian Acacias, or the position of the surfaces is changed, as in Eucalyptus.

as **parallel-veined** leaves, and are characteristic of monocotyledons; and the latter as **reticulately veined** leaves, distinguishing the dicotyledons. Reticulately veined leaves may be further subdivided into **palmately veined,** as in geranium or podophyllum, where the secondary veins arise from the base of the midrib and diverge to the periphery of the leaf; and feather-veined or **pinnately veined,** as in chestnut, where the secondary veins arise from the midrib like the plumes on the shaft of a feather.

(*d*) FORMS OF LEAVES.

The leaves of plants exhibit an almost innumerable variety of forms; even on the same plant there are not infrequently several forms, as in *Viola tricolor* and sassafras. Many of the terms used in ordinary language in describing the forms of objects are applied here also, as linear, lanceolate, oblong, elliptical, spatulate or wedge-shaped, etc.

Apex.—A number of descriptive terms are employed in describing the apex of the lamina, as acute, when the form is that of an acute angle; obtuse, when the angle is blunt; acuminate, when the angle is prolonged; truncate, when the end of the leaf appears to be cut off; retuse, when it is slightly notched at the apex; obcordate, when the notch is pronounced; emarginate, when the degree of notching is between retuse and obcordate. Sometimes the apex appears like the continuation of the midrib, when it is termed cuspidate or mucronate.

Base.—Some of the terms used in describing the general outline, as well as the apex of the leaf, are also applied to the base, as obtuse, truncate, cordate, reniform, etc. Other terms, however, especially apply to the base, as cuneate or wedge-shaped; connate-perfoliate, when opposite leaves are connected at the base and

surround the stem; perfoliate, when the leaf simply clasps the stem.

Margin.—Very few leaves possess an even margin, and according to the degree and character of the incisions or indentations they are described as serrate, when the apex of the divisions or teeth is sharp and directed forward like the teeth of a saw; dentate, when the divisions project outward; crenate, when the teeth are more or less rounded; repand, when the margin is somewhat wavy; sinuate, when the wavy character is pronounced; lobed, when the incisions extend not more than half-way into the lamina and the sinus (or portion cut out) and the lobe are more or less rounded; cleft, when the incisions are still deeper and the sinuses and lobes are somewhat acute; and parted when the incisions extend almost to the midrib.

(*e*) COMPOUND LEAVES.

The divisions of a parted leaf may assume the form of a simple leaf when the divisions are known as leaflets and the whole as a compound leaf. The distinction between a simple leaf and a leaflet is, that the former has a bud in the axil. Compound leaves may be divided into pinnately compound or palmately compound, this distinction depending upon whether the leaflets are arranged pinnately or palmately. A number of forms of pinnately compound leaves are recognized, but these will not be considered here. The leaflets of compound leaves may themselves be divided, forming decompound leaves, as in *Dicentra* and the honey locust. The same terms are used for describing the form, apex, margin, etc., of the the leaflets of compound leaves as are used for simple leaves.

The following outline shows the principal classes of simple and compound leaves:

I. Simple leaves (axillary bud at the base).
  (1) Parallel veined.
  (2) Reticulately veined.
    (*a*) Pinnately veined.
    (*b*) Palmately veined.

II. Compound (leaflets without axillary bud).
  (1) Pinnately compound.
  (2) Palmately compound.

(*f*) STRUCTURE OF THE LEAF.

The leaf usually consists of three kinds of tissues: (1) epidermal, (2) parenchymatous, and (3) fibrovascular; in some cases there may also be a development of collenchyma.

The **Epidermis** forms the surface of the leaf and may consist of one or more layers of cells. The outer walls are cutinized, and when nearly smooth the leaf is said to be **glabrous.** They may contain wax in addition, as in senna, when the leaves are spoken of as **glaucous.**

In other cases the outer walls of the epidermal cells are modified to hairs. When the hairs are unicellular and lie over one another in one direction, they give the leaf a **sericeous** or silky appearance; when they are very short and straight, the surface is described as **puberulent**; or when they are still longer, as **pubescent**; or when long and straight, as **pilose**; when the hairs are long and matted togther, as **tomentose,** or woolly; when they are hard and prickle-like, the leaf is spoken of as **hispid,** or **strigose**; when modified to spines, as **spinose,** and **echinate,** when they are hooked.

In still other cases the epidermal cells are uneven, forming depressions and protuberances which, if slight, the surface is described as **rugose**; or if wart-like, as **varicose.** Furthermore, the veins may be quite prominent, particularly on the lower surface, and if they are

much reticulated in addition, the surface is described as being **reticulate.**

The epidermal cells are further characterized by the development of stomata and water-pores, the origin and function of which have already been described.

The parenchyma of leaves, known as **mesophyll,** may be of two kinds: one in which the cells are nearly isodiametric, or branching, and between which are large intercellular spaces; and another, consisting of elongated cells, which are compactly arranged, and known as the **palisade cells.** The latter usually occur beneath the upper epidermis, as in coca, digitalis and hyoscyamus; or they may occur upon the lower surface as well, as in senna; or they may constitute the entire parenchyma of the leaf, as in eucalyptus. Oil-secretion reservoirs are sometimes found in the parenchyma, as in pilocarpus and eucalyptus, when the leaf is said to be **pellucid-punctate.**

The fibrovascular tissue of the leaf consists of xylem and phloem, surrounding which is a layer of cells corresponding to the endodermis or bundle-sheath of the young stem. This tissue is found in the middle of the veins, the phloem being situated on the side toward the upper surface of the leaf, and the xylem toward the under surface. Collenchyma is frequently found under the epidermis of the veins of the leaves, as in *Mentha piperita*, senna and stramonium.

(*g*) PHYLLOTAXY OR PHYLLOTAXIS.

Phyllotaxy, or phyllotaxis, is the study of the distribution of leaves upon the stem, and of the laws which govern it. If we examine germinating plants of the beech, the elm, or the oak, we observe that, while the seed-leaves are opposite to each other, the subsequent leaves are arranged according to a different order

in these several plants, but in a definite manner in each. In the elm, the distribution of the leaves is such that the third leaf is directly above the first; in the beech, the fourth leaf is above the first, and in the oak, the sixth leaf is above the first. If these leaves are connected in the order of their arrangement, it will be seen that they describe a spiral in their development, and it will also be found that one or more turns are made between the superimposed leaves. Furthermore, it will be found that this arrangement constitutes a mathematical series which may be expressed in degrees, or the parts of a circle that the leaves are from each other, this measure being known as **divergence**; or by the number of perpendicular rows of leaves on the stem which are known as **orthostichies.**

The following may serve to illustrate the terms used:

	Divergence.		Orthostichies.
	Degrees.	Parts of a circle.	
Elm	180	$\frac{1}{2}$	Distichous.
Beech	120	$\frac{1}{3}$	Tristichous.
Oak	144	$\frac{2}{5}$	Oentastichous.

If we examine the fractions used, we will find that the numerator indicates the number of turns around the stem before encountering a superimposed leaf, and that the denominator indicates the number of leaves found; the latter also expresses the number of orthostichies. On adding the numerators and denominators of any two successive fractions, a fraction is obtained which expresses the next highest arrangement, as $\frac{1}{2} + \frac{1}{3} = \frac{2}{5}$.

In quite a number of plants two leaves arise at the nodes, as in the Labiatæ. These are invariably situated opposite each other on the stem, and the successive pairs alternate with one another, forming the **decussate** arrangement of leaves.

(*h*) MODIFIED LEAVES.

Leaves are variously modified and serve for other purposes than those already described. They may be fleshy in character and serve as storehouses for nutritive material, as seed-leaves, or they may serve for the storage of water, as in Agave and Aloe. In some instances, particularly when situated near the flowers, they lose their green color, as in the dogwood, skunk cabbage and others. In other cases they are modified so that they serve as a trap for insects, as in species of *Sarracenia* and *Drosera*. The petiole may become enlarged and perform the functions of the leaf, as in the acacias, of Australia; or they may serve as a means for floating the plant, as in the water hyacinth. The stipules may likewise be modified, becoming leaf-like, as in the pansy, or metamorphosed into thorns, as in the locust. In some cases the leaves are very much reduced, their functions being performed by the stem, as in Cactaceæ, or even by the roots, as in some orchids.

(*i*) PREFOLIATION OR VERNATION.

Prefoliation or vernation is the disposition of leaves in the bud. The terms used to describe the folding of the leaves in the bud are derived from an examination of transverse sections of the bud. The following are some of the terms which are employed: **conduplicate**, when the lamina of the leaf is folded lengthwise along the midrib so that the two halves of the upper surface lie together, as in the Magnoliaceæ; **plicate** or plaited, when the lamina is folded along the veins, like a closed fan, as in the maples; **convolute**, when rolled lengthwise and forming a coil in cross section, as in the Rosaceæ; **involute**, when both margins are inrolled lengthwise on the upper surface, as

in the violets; **revolute**, when both margins are inrolled lengthwise on the lower surface, as in azalea.

In addition, there are several terms used which are derived from the appearance of the bud, as **reclinate** or inflexed, when the upper part is bent on the lower, as in Liriodendron; and **circinate**, when the upper part is coiled on the lower, as in the ferns.

B. REPRODUCTIVE PARTS OF THE PLANT.

I. THE FLOWER.

It is well known that if a portion of the stem of a plant, including one or more nodes, be placed under suitable conditions for growth, it will form roots and a new plant will be developed. This method of increasing the number of individuals is frequently resorted to by horticulturists, and is known as asexual reproduction or **propagation.** It is fortunate, however, that owing to the special conditions required in this method of perpetuation and distribution of species, other methods of reproduction are followed in nature, the most important of which depend upon the development of flowers and the production of seed.

The flower may be looked upon as a modification of the stem and leaves to this end, and the continuing of the species by this means is known as **true reproduction,** or sexual reproduction. Considering the flower then as in the nature of a modified branch, it is seen that in both of these modes of reproduction the node, which together with the internode constitutes a **phytomer,** are essential.

The nature and origin of the flower and its relationship to the branch are ordinarily not apparent, except in cases of reversion; that is, where the parts of the flower assume the appearance of leaves or branches.

(*a*) SIMPLE FLOWERS.

A complete flower consists of the following parts: (1) pistils, (2) stamens, (3) petals and (4) sepals. These are situated at the extremity of a branch known as a flower-stalk. The parts of the flower are arranged in circles or rows, one above or within the other, the calyx being below or external, followed successively by the corolla, stamens and pistil, the latter terminating the floral axis. The point of attachment is somewhat enlarged and is known as the **torus** or **receptacle.** The leaf occurring at the base of the flower-stalk is usually modified in form and frequently in color and is known as a **bract.** In an incomplete flower one or more of these parts may be wanting. The simplest kind of a flower consists of but one part as either a single pistil or a single stamen, as in the willows and poplars.

The **pistil** consists of the following parts: A somewhat enlarged lower part, known as the **ovary,** which is hollow and contains more or less rounded bodies, known as **ovules,** and which, under proper conditions, finally develop into seeds; the ovary is prolonged into a stem-like part called the **style,** which is terminated by a slightly enlarged portion known as the **stigma.** A flower which produces only a pistil, or pistils, is known as a **pistillate flower.**

The **stamen** consists of a stalk, known as the **filament,** and is terminated by a more or less ellipsoidal body, known as the **anther.** The latter contains a yellowish powdery substance, called **pollen.** A flower that consists of a stamen, or group of stamens only, is called a **staminate flower.**

The stamens and pistils constitute the essential or reproductive parts of the flower, and when they are both present in one flower it is known as a **perfect flower.**

In many flowers there is an additional part which is usually green and leaf-like, as in Cannabis Indica, known as the **calyx**, the individual parts being known as the **sepals.**

A great many flowers produce, in addition to calyx, stamens and pistils, another circle of parts which, as a rule, are quite bright and attractive, as in the rose, geranium, violet, etc. This circle of parts is situated between the calyx and the stamens and is called the **corolla**, the individual parts being termed **petals.**

The calyx and corolla are regarded as the non-essential parts of the flower and together constitute the **perianth** or **perigone.**

A complete flower is said to be **symmetrical** when the number of parts in each circle is the same or a multiple of it; as a rule the number of stamens is some multiple of one of the other parts, as in geranium, where we find five sepals, five petals, ten stamens and five pistils.

Flowers are also spoken of as **regular** or **irregular,** according to whether all the parts of a circle are uniform in shape or not; the flowers of geranium are regular while those of violets are irregular.

Pistillate and staminate flowers may be borne upon the same plant, as in white-oak or castor-bean, when the flowers are said to be **monoecious**; or they may be borne upon separate plants, as in willows and poplars, when they are said to be **dioecious.**

(*b*) COMPOUND FLOWERS.

The flowers of the Compositæ are borne on an enlarged receptacle, which is subtended by one or more circles of bracts, these constituting an **involucre.** The flowers are of two kinds, and they receive different names because of their form and position. Those situ-

ated near the margin of the receptacle are known as **ray-flowers**, and because they possess more or less strap-shaped corollas are also known as **ligulate flowers.** Those occupying the central portion of the receptacle are known as **disk-flowers,** or **tubular flowers,** because of the tubular shape of the corolla. Most of the Compositæ possess both ligulate and tubular flowers, as arnica, matricaria, the common daisy, etc. A number of the other members of the family have only ligulate flowers, as chicory and dandelion; and a relatively few have only tubular flowers.

(*c*) PREFLORATION OR ESTIVATION.

Prefloration or estivation is the arrangement of the parts of the flower—more especially the calyx and corolla—in the bud. Some of the terms used in this connection are also employed in the study of vernation. The following are some of the terms which are employed: **Valvate,** when the sepals or petals meet each other at the edges, as in Malvaceæ; **imbricated,** when the sepals or petals overlap each other, as in the Magnoliaceæ; **plicate** or **plaited** is applied to petals when they are united and folded together, as in *Convolvulus* and *Datura.*

The sepals and petals do not necessarily possess the same arrangement, as in the Onagraceæ, where the sepals are valvate and the petals are convolute. Furthermore, in addition to the principal types of estivation and vernation already given, there are a number of special modifications of these, depending upon the number and arrangement as well as direction of the overlapping parts of the flower or leaf-bud.

(*d*) ANTHOTAXY.

Just as a flower may consist of one or more parts, so a flower-branch may bear more than one flower. The

stalk of the individual flowers is called a **pedicel**, while the main axis, or branch bearing the collection of flowers, is called a **peduncle**. The study of the arrangement of flowers on the stem is known as Anthotaxy.

If we compare the flower clusters of morning glory with those of the poke weed, we will find that in the former the number of flowers that may be produced is limited because the middle flowers of the group, corresponding to the apex of the branch, mature first; in the poke weed, on the other hand, the end of the branch has a large number of flower buds, and as these develop others continue to be formed. It is obvious that in the latter case the number of flowers that may be produced is more or less indefinite, and this kind of anthotaxy, or inflorescence, is known as **indeterminate or indefinite inflorescence**, while in the case of the morning glory, the inflorescence is said to be **determinate** or **definite**.

The indeterminate or indefinite inflorescence is the most general and includes the following kinds: In poke weed the individual flowers are of about the same size, and these are arranged along a central axis, or **rachis**, the inflorescence being known as a **raceme**; in cusso the individual flowers are replaced by a cluster of flowers, constituting a compound raceme or **panicle**; in the cultivated cherry the rachis is somewhat shorter than in the raceme, and the pedicels of the flowers are so elongated that all of the flowers attain nearly the same height or level, this form of inflorescence being known as a **corymb**; in the milk weed the rachis is entirely suppressed and the flowers, which have pedicels of the same length, arise from a common receptacle, this form of inflorescence being known as an **umbel**; in the Umbelliferæ a flower cluster takes the place of the individual flowers of the umbel, and this is known as a

compound umbel; in the plantain the flowers are arranged along a central axis, but the pedicels are wanting, and the inflorescence is known as a **spike**; in clover, *Cephalanthus* and the Compositæ, the rachis and pedicels are both more or less suppressed or wanting, and this form of inflorescence is known as a **head.** In the Compositæ the head is in addition, subtended by an involucre.

The determinate or definite inflorescence includes several types, the principal of which may be mentioned: when a stem or branch is terminated by a flower, it is known as a **cyme**, and inflorescence of this character is described as cymose; when the peduncle bears a number of cymes, it is known as a **compound cyme**, as in elder, hydrangea and viburnum; and a cymose head is known as a **glomerule**, as in the dogwood. When the cymes are opposite and sessile, or nearly so, the inflorescence is termed a **verticillaster**, as in the Labiatæ.

(*e*) MODIFICATIONS OF THE FLOWER.

The parts of the same circle of the flower or even of different circles may be united, and a number of terms are used to describe these modifications. When the parts of the same circle are united there is said to be a **cohesion** or **coalescence** of the parts. When the parts of different circles are united, as of calyx with corolla, the union is spoken of as **adhesion** or **adnation.**

In addition to pure adhesion among the different parts of the flower there may be developed, either beneath, around or upon the ovary, a somewhat fleshy part, which is usually a modification of the receptacle and is in the nature of a nectar-secreting apparatus. This is known as a **disk.**

The arrangement of the other parts of the flower

with reference to the ovary and disk is spoken of as **hypogynous**, when they arise beneath the ovary or disk, as in the orange flower; **perigynous**, when the stamens or petals are inserted upon the calyx or disk around the ovary, as in the rose; and **epigynous**, when the remaining parts of the flower arise from the upper portion of the ovary, as in the clove.

When the other parts of the flower are hypogynous the ovary is spoken of as **superior** or "free," because it is above the other parts and free from any adhesion. Likewise, when the other parts are epigynous, the ovary is said to be **inferior**, because it appears to be beneath them, on account of their adhesion with it.

Upon examining a large number of the flowers of water lilies, and those of cultivated and wild roses, it will be found that the stamens and petals of some of the flowers have undergone a transformation or metamorphosis. In the flowers of the water lily some of the petals are metamorphosed into stamens and this change is spoken of as **progressive metamorphosis**, there being a change from non-essential to essential elements. In the rose, on the other hand, the effect of cultivation is that of a **retrograde metamorphosis**, some of the stamens being changed to petals. This transformation is observed in all of the "double flowers" of the florist, as roses, and also occurs naturally, as in the buttercups. Retrograde metamorphosis, when complete, includes the pistil as well as the stamens. In the case of green roses and green strawberries the petals may also become green and leaf-like, and the change is spoken of as "Chlorosis" or "Chloranthy." In some flowers even the ovules are reverted to leaf-like processes or appendages, as in *Drosera* and clover.

In the water lily and rose it was observed that there was an increase of the parts of one circle at the expense

of one or more of the other circles; there may, however, be an increase in the number of parts of a circle by simple division of the parts without involving any other part of the flower, and this is known as **chorisis** or **deduplication**; an instance of this is seen in the stamens of the orange blossom, where from a single stamen a group of from three to eleven stamens may be produced. Instead of an increase there may be a decrease in the number of parts. When there is a partial loss of the element, as of the anther of the stamen in the Catalpa flower, the stamen is said to be imperfectly developed or **abortive**. When the entire element remains undeveloped, as in the stamens of the Labiatæ, it is said to be **suppressed**.

1. CALYX AND COROLLA.

As already stated the calyx and corolla, like the other parts of the flower, may consist of a number of separate divisions when they are spoken of as **chorisepalous** and **choripetalous**, respectively; or when the divisions are united they are known as **gamosepalous** (monosepalous, synsepalous) and **gamopetalous** (monopetalous, synpetalous), respectively.

When the parts of the calyx or corolla are entirely united they are said to be **entire**, and when they are partly united they are spoken of as "toothed," "lobed" or "parted," according to the degree of union.

In the flowers of the Cruciferæ and Caryophyllaceæ there is a conspicuous stalk to each of the separate petals, which is known as the **unguis** or **claw**; while the upper outspreading portion is known as the **lamina** **or** blade. In the gamosepalous calyx and the gamopetalous corolla the lower united portion is known as the **tube**, and the upper outspreading portion as the **limb** or "border."

The form of the calyx and corolla is quite characteristic for a number of important families. In the Compositæ there are, as has already been pointed out, two characteristic forms of corolla, namely, the tubular in the disk flowers and the ligulate in the ray flowers; in the Papilionaceæ the corolla, from its fancied resemblance to a butterfly, is described as **papilionaceous**; in the Labiatæ the petals are united into two lip-like developments, and the corolla is said to be **bilabiate.** There are two kinds of bilabiate corollas—one, as in lavender, where the mouth of the tube is open, and known as **ringent**; and another, where the mouth is closed, as in *Linaria*, and called **personate.**

There are a number of other special forms of calyx and corolla, particularly the latter, and of these may be mentioned the following: a corolla, like that of the harebell, which is more or less bell-shaped, is termed **campanulate**; a more or less campanulate corolla contracted near the opening, as in *Gaultheria*, is spoken of as **urceolate** or urn-shaped; in the morning glory and other Convolvulaceæ the corolla is said to be **infundibuliform** or funnel-shaped; a corolla, in which the limb spreads abruptly from the tube, as in *Phlox*, is termed **hypocrateriform** or salver-shaped; a corolla with a short tube and an outspreading limb, as in potato, is said to be **rotate** or wheel-shaped; a rotate corolla with the margin more or less upturned is called **crateriform** or saucer-shaped; in aconite the upper petal is hood or helmet-shaped, the corolla being spoken of as **galeate**; in the violets one of the petals has a spurred appendage and the corolla is described as **saccate** or calcarate, and the modified petal in the orchids is known as a **labellum.**

Duration of Calyx and Corolla.—There is considerable difference in the length of time that the calyx and co-

rolla persist, not only with reference to each other but in different plants. The parts are said to be **caducous** when they drop from the flower as soon as it opens, as the calyx of the poppy; when they remain for a day or so, they are said to be **ephemeral** or fugacious, as in the petals of the poppy; in the rose and apple the petals fall away soon after the pollen reaches the stigma and they are said to be **deciduous**; in some flowers the petals wither but persist until the maturing of the fruit, as in the Droseraceæ, and are known as **marcescent**; the calyx may remain unaffected until the maturing of the fruit, as in the Labiatæ, when it is said to be **persistent**; in the apple the calyx grows and becomes fleshy with the development of the ovary, when it is said to be **accrescent.**

2. THE STAMENS.

When a flower has but one stamen it is termed **monandrous**; and when there are two, three or many stamens, it is said to be diandrous, triandrous or polyandrous. The aggregate of stamens in a flower is called the **androecium.** In the Labiatæ there are four stamens arranged in a longer and shorter pair and the andrœcium is said to be **didynamous**; in the Cruciferæ the flowers possess six stamens, four of which are longer than the other two, and the andrœcium is described as **tetradynamous**; in some plants, as in the Lobeliaceæ, Papilionaceæ, etc., the filaments of the stamens cohere, forming groups which are termed monadelphous, diadelphous, etc.; in the flowers of the potato the anthers lie close together but are not united, forming apparently a closed ring around the pistil, when they are said to be **connivent**; in the tubular flowers of the Compositæ the anthers are united, forming a closed ring, and the stamens are spoken of as **syngenesious**; in the flowers

of the Orchidaceæ the stamens are borne upon the pistil and are said to be **gynandrous.**

The **Anther** is the essential part of the stamen and consists of two lobes, each of which is composed of two divisions or sacs. These sacs contain the pollen which is discharged either through a longitudinal suture or line of dehiscence, or through an opening at the tip. The anthers may be variously attached to the filament: when they face toward the axis of the flower they are said to be **introrse,** as in the Violaceæ and when they face toward the perianth they are said to be **extrorse,** as in the Magnoliaceæ; when they lie horizontally on the tip of the filament, so that they swing as on a pivot, as in the tiger lily, they are said to be **versatile**; when they adhere longitudinally to the sides of the filament and the dehiscence is marginal, they are said to be **innate**; when they adhere longitudinally to the filament and the latter extends slightly beyond them, they are said to be **adnate,** in which case they may be extrorse or introrse. In some of the Labiatæ the lobes of the anther are united at the apex of the filament, but diverge from the point of attachment and are said to be connate, coherent or **Confluent.**

The **Connective** is that portion of the filament to which the lobes of the anther are attached or which connects them; usually, it is not very prominent; but in some of the Labiatæ, as in *Salvia,* it is rather broad; in some of the Malvaceæ it is entirely wanting, the two lobes being confluent; in other cases it may be extended beyond the lobes of the anther, as in species of *Asarum.*

Appendages of Anther.—In certain instances the anthers are appendaged: in the violets there is a triangular growth at the apex; in the oleander the apex is plumose; in *Polycodium stamineum* there are two awn-like

developments upon the back of the anther; in the violets the two stamens that project into the spurred petal are also spurred and secrete a nectar; in the Asclepiadaceæ the anthers possess wing-like appendages, each sack or division of which contains a pear-shaped coherent mass of pollen grains, and these are connected with the stigma in pairs.

3. THE PISTIL.

The pistil being considered in the nature of a modified leaf, the term **carpel** or carpophyl has also been applied to it; and the aggregate of pistils or carpels in a flower constitute the **gynœcium.** According as the gynœcium consists of one, two, three or many carpels, it is said to be monocarpellary dicarpellary, tricarpellary or polycarpellary. When the carpels are separated from one another, as in the buttercups, or cherry blossoms, the gynœcium is said to be "simple" or **apocarpous.** When the carpels cohere, as in the orange flower, the gynœcium is spoken of as being "compound" or **syncarpous.**

The pistil of the flower of the pea consists of an elongated ovary, a short style and a stigma; upon dissecting the ovary and also making a transverse section of it, it is observed that the ovules are borne upon the edge or part which projects into the cavity, and this part is known as the **placenta,** the united margins of the carpel forming the "inner" or **ventral suture.** When the gynœcium consists of a number of carpels, the ventral suture is directed toward the axis of the flower; in some cases that portion of the carpel corresponding to the midrib is very prominent, as in the Papilionaceæ, and has received the name of "outer" or **dorsal suture.**

There are as many cavities or cells in the ovary as there are carpels, and the walls or partitions between

the cells of a syncarpous gynœcium are known as **dissepiments**; when three or more carpels are united the number of dissepiments corresponds to the number of carpels. It sometimes happens that a partition or wall is intruded from the mid-vein of the carpel, dividing a one-celled ovary into one that is two-celled, as in species of *Astragalus*, and such a partition is termed a **false dissepiment.**

When no other than the true dissepiments exist in the syncarpous gynœcium the placentæ are borne along the axis of the flower and are termed **axial placentæ.** In the Caryophyllaceæ the ovules are borne upon a central axis, and the dissepiments having been absorbed the gynœcium is said to possess **free central placentæ.** In other cases the placentæ grow backward from the central axis toward the mid-vein of the carpel, carrying the ovules with them, when they are spoken of as **parietal placentæ.**

The **Style** not only varies in shape and size but in the manner of attachment to the ovary; it may be very short, as in the clove; long and filiform, as in *Œnothera;* club-shaped (clavate) as in the orange; or broad and petalloid, as in *Iris.* It is usually situated at the summit of the ovary when it is said to be apical or terminal; it may, however, be laterally attached, as in the strawberry, or in a few instances attached to the base of the ovary. It is usually smooth, but may be hairy, as in the Compositæ. The styles like the carpels may be separate or united, and in the latter case may have a central canal connecting the stigma with the ovary, as in the violets. While usually deciduous, the style may be more or less persistent—forming a part of the fruit—or even develop additionally, as in the dandelion.

The **Stigma** is an essential part of the pistil in that

it is the germinating ground of the pollen grains, it being viscid and especially adapted for this purpose. The stigmas may be separate, as in the Compositæ, or they may be united into a more or less club-shaped or globular head, consisting of as many lobes as there are stigmas, as in the poppy. The stigma, while usually solid, may have an opening, as in the violets, which sometimes has a lid-like appendage, as in *Viola tricolor*.

The **Ovules**, as we have already seen, are small bodies which are borne on the placentæ, and which, after fertilization, develop into seeds. The number of ovules varies considerably—there may be but one, as in the almond, or there may be a large number, as in the watermelon. A complete ovule consists of (1) a stalk; (2) two coats—an outer and an inner; (3) a narrow orifice for the entrance of the pollen tube, called the **foramen**; (4) a portion inclosed by the coats, known as the **nucellus**; (5) a more or less differentiated portion imbedded in the nucellus near the foramen, known as the **embryo sac**, and in which, after fertilization of the egg-cell, the embryo is formed. That portion of the ovule where the nucellus and coats grow together is known as the **chalaza**.

There are several principal forms of ovules recognized, of which the following may be mentioned: (1) **orthotropous**, in which the ovule is straight and erect on its stalk, as in the Urticaceæ; (2) **anatropous**, in which the ovule is bent over on to the stalk so as to be in an inverted position, the line of attachment of the ovule and stalk being known as the **raphe**; most of the ovules of flowering plants belong to this group; (3) **campylotropous**, in which the ovule is bent upon itself, as in *Stramonium*, this form being less frequent than the other two.

(*f*) POLLINATION AND FERTILIZATION.

All the elements that we have thus far considered, namely, the gynœcium, andrœcium, corolla, calyx, bracts and nectar apparatus, play a role in the production of seed. The transferral of the pollen from the anther to the stigma and its subsequent germination constitute **pollination**. At the time that the ovules of the species to be pollinized have matured, the anthers ripen and discharge their pollen. When the pollen is discharged upon the stigma of the same flower the process is called close or "self-pollination;" but when the pollen from one flower is carried to the stigma of another flower, by aid of the wind or water, or by animals, as insects and birds, or in other ways, the process is called "cross-pollination." In the process of germination the pollen grain develops a long tube-like process which penetrates the tissues of the stigma and style and, finally reaching the foramen of the ovule, it pushes its way through the cells of the nucellus to the embryo sac, where it discharges a cell known as the **generative cell** which unites with a cell in the embryo sac, known as the **egg-cell**. It is from the union of these two cells that the embryo develops, and this union of generative cells is known as **fertilization**, two kinds being distinguished, namely, "self-fertilization" and "cross-fertilization," depending upon whether self-pollination or cross-pollination has been effected.

(*g*) INNER MORPHOLOGY OF THE FLOWER.

The inner morphology of the flower bears a close resemblance to the structure of the stem and leaf. The **bracts** in almost all particulars are like the foliage leaf of the same plant and the **flower stalk** closely resembles the foliage stem. The **calyx**, while resembling the foliage leaf, usually contains calcium oxalate in greater

amount, and the mesophyl consists wholly of rather loose chlorophyl parenchyma; the outer or under epidermis contains the stomata, and if hairs are present, they also arise from this surface; the fibrovascular bundles are generally simple in structure, although in some cases, as in lavender, sclerenchymatous fibers are strongly developed.

In the **corolla** the epidermal cells are generally more or less centrifugally developed, forming prominent papillæ, which give the petals a velvety or satiny appearance, as in the rose; secreting and non-secreting hairs are also developed, which are peculiar to the corollas of irregular flowers, as in *Lavandula vera* and *Viola tricolor;* stomata are comparatively few in number. The epidermal cells are but slightly cutinized, and in surface view are strongly undulate and appear striate owing to the papillary development. The mesophyl is made up of rather loose, branching parenchyma cells, with large intercellular spaces, which are free from chloroplastids and may contain, like the epidermal cells, a colored sap, or chromoplastids; in some instances, as in the buttercups, starch grains are also found in the mesophyl. Calcium oxalate crystals are usually present, and milk vessels are sometimes found, as in the Papaveraceæ.

The **filament** and connective possess a central fibrovascular bundle, around which are arranged comparatively small parenchyma cells and among which secretion cells are sometimes scattered, as in *Tilia.* The **pollen sacs** consist of but two layers of cells—an outer layer called the "exothecium," which resembles the epidermis of the corolla, and an inner layer called the "endothecium," the cells of which are contractile and peculiarly thickened, this feature being rather characteristic for certain species. Lining the pollen sacs,

during their development, there is a layer of cells, the so-called "tapetal cells;" but these are usually sooner or later absorbed.

The **pollen grains** vary greatly in number, as well as in size and shape. They are usually more or less ellipsoidal but may be spherical, as in *Crocus;* more or less three-sided, as in the Compositæ and in cloves; four or five-sided, as in *Viola tricolor*, and in some cases, as in the Coniferæ, they may be winged. Pollen grains contain protoplasm, one or more nuclei and considerable oil and starch; the covering or inclosing membrane consists of two parts, the inner of which is known as the "intine" and consists of cellulose, and the outer, known as the "exine," apparently consists chiefly of cutin; in some cases the exine also contains an oil which is colorless, as in *Salvia*, or yellowish, as in lavender, and in some instances it may contain a viscid substance, causing the pollen grains to adhere, as in *Œnothera*. The grains may be smooth or variously sculptured; in most instances the exine is unevenly developed, leaving thin places through which the pollen tubes protrude in germination; these give the appearance of grooves when the grains are dry, and the number of grooves are characteristic for different species; in most of the Compositæ they are three in number; in the Labiatæ there are six, while in *Crocus* they are wanting.

The epidermal cells of the **stigma** are quite characteristic: the cells of the epidermis, or so-called "stigma-epithel," may be palisade-like, forming a more or less wart-like mass as in the viscous stigmas of the Umbelliferæ, or the outer walls may be modified to rather long, broad papillæ, as in matricaria and arnica, or they may be developed into hair-like processes, as in *Crocus*. The germinating pollen tubes enter the style through an open canal, as in the violets, or they penetrate into the

conducting tissues of the style, either through the papillæ, as in *Malva*, or through the middle lamella of two neighboring papillæ, as in *Atropa Belladonna.*

The important tissue of the **style** is the conducting tissue; in styles which are hollow it forms the lining of the canal, the cells resembling those of the stigma-epithel; in styles that are solid the conducting tissue occupies the central axis and consists of somewhat elongated cells, the walls of which are generally thick, frequently strongly refractive and possess the property of swelling, being furthermore separated by large intercellular spaces. Surrounding the conducting tissue are thin-walled parenchyma cells, in which the fibrovascular bundles are distributed, the number of groups of the latter corresponding to the number of carpels that compose the gynœcium. There may also occur secretion cells, containing mucilage, as in *Malva*, or oil and resin, as in matricaria. Occasionally, the parenchyma is replaced either in part or entirely by mechanical cells, and the epidermal cells may be modified to hairs.

The tissues of the **ovary** are, as a rule, in a very rudimentary condition; in fact, so rudimentary that it is difficult to distinguish the ovaries of two flowers that develop into quite different fruits. In some instances it is said that notwithstanding the subsequent changes, each cell of the fruit is already indicated in the ovary. The ovary possesses an outer and an inner epidermis; the outer is provided with stomata and may also possess hairs; the inner may also have stomata and after fertilization may develop secretion hairs, as in the orange. Between the epidermal layers occur thin-walled parenchyma cells which contain leucoplastids and chloroplastids, and in which the fibrovascular bundles are distributed, these being usually simple or else

quite complicated, as in the pea. The number of fibrovascular bundles is more or less dependent upon the number of carpels that make up the gynœcium; as a rule, there is a strong fibrovascular bundle which corresponds to the midvein of each carpel.

The **placenta** is a development from the inner epidermis, and is traversed by a fibrovascular bundle from which branches are given off to the individual ovules; it may have a conducting tissue similar to that found in the style, and in some cases the epidermis of the stalk of the ovule may be developed to a stigma-epithel.

The **ovule** not only possesses a distinct form as already given, but the internal structure, by reason of the changes associated with fertilization, is more or less characteristic for certain species and genera. It has an epidermal layer, the outer walls of which are more or less cutinized, and it consists for the most part of parenchyma cells rich in organized cell-contents and food-materials; and in addition the embryo sac contains a number of nuclei. The stalk and raphe are connected with the placenta by means of a fibrovascular bundle.

The **nectar** may be secreted by the epidermal cells of various parts of the flower; these may resemble the ordinary epidermal cells or they may be modified to papillæ, as in the spurred stamens of the violets, or to hair-like processes, as in *Malva*. The cells which secrete nectar constitute the "nectar-apparatus," and the walls are usually thin and more or less cutinized. The nectar-apparatus is found more generally upon some part of the stamen, while the calyx and corolla are not infrequently hollow or spurred at the base, which adapts them for holding the nectar, as in *Liriodendron*, *Tropæolum*, and the violets.

II. THE FRUIT.

As a result of the fertilization of the ovule or ovules, the parts of the flower that play no further part either in protecting the seed or aiding in its dispersal soon wither and are cast off; in most flowers the petals lose their color and, together with the stamens, style and stigma, wither and fall away shortly after fertilization. The stigma may, however, persist, as in the poppy; the style may likewise remain, as in *Ranunculus*, or even continue to grow, as in *Taraxacum;* in other cases the calyx persists, as in orange and belladonna, or it may unite with the walls of the ovary and continue to grow with them, becoming fleshy, as in pimenta and apple. The fruit may consist, therefore, not only of the ripened pistil, but also of other parts of the flower which persist or develop with it.

The wall of the fruit is called a **pericarp**, and like the leaf, it consists of three distinct layers, viz.: (1) the outer layer corresponding to the outer epidermis of the ovary is called the **epicarp** or **exocarp**; (2) the inner layer corresponding to the inner epidermis of the ovary is called the **endocarp**, or, from the fact that it is sometimes hard and stone-like, it is sometimes called the **putamen**, as in the prune; and (3) a middle layer situated between the epicarp and endocarp, which is called the **mesocarp**; and from the fact that it is sometimes succulent or fleshy, as in the prune, it is also called the **sarcocarp**.

There are a number of distinctive and descriptive names applied to fruits. Some of the more important are the following:

An **Achene** is a non-fleshy, or so-called dry, one-celled and one-seeded, indehiscent fruit, in which the pericarp is more or less firm, and while not united with the seed, the latter almost completely fills the cavity formed

by it; achenes may be inferior, as in the Compositæ, where the calyx persists; or they may be superior, as in the rose, where they are free from the calyx; or they may be imbedded in a fleshy receptacle, as in the strawberry.

A **Berry** is a fleshy, indehiscent fruit, the seeds of which are imbedded in a sarcocarp; berries are superior when free from the calyx, as in belladonna, capsicum, grape, etc., and inferior when there is an adnation of the calyx, as in banana, cranberry and gooseberry.

A **Capsule** is a dry, dehiscent fruit, consisting of two or more carpels. Dehiscence in capsules may occur in five different ways: in the castor-bean the carpels separate from each other along the walls or septa (dissepiments), the seeds being discharged along the ventral suture of the separated carpels, and this mode of dehiscence is called **septicidal.** In mustard the dissepiments remain intact and dehiscence occurs along the margin of the capsule, and is therefore called **marginicidal**; but as the partial carpels, or **valves** as they are termed, separate from the walls or septa, the dehiscence is also known as **septifragal.** In cardamom the septa as well as valves are united, and at maturity the latter separate and dehisce at points in the margin corresponding to the mid-vein of the modified leaf or carpel, the cells or loculi being broken into; this form of indehiscence is known as **loculicidal.**. In poppy capsules there are a few openings beneath the united stigmas through which the seeds are expelled, and this form of dehiscence is known as **porous.**. In hyoscyamus a portion of the capsule comes off from the remainder like a lid, and this form of dehiscence being irregular or abnormal to the sutures of the carpel, it is called **circumcissile.** A capsule of this kind is known as a **Pyxis.**

A **Caryopsis**, or Grain, is an indehiscent, non-fleshy

fruit possessing a thin pericarp, w hih is closely adherent to the thin seed coats, as in wheat, corn and other Gramineæ.

A **Cremocarp** is a dry indehiscent fruit which consists of two inferior achenes, known as **mericarps**; these are separated from each other by means of a stalk known as a **carpophore.** This fruit is characteristic of the Umbelliferæ.

A **Drupe** is a fleshy, indehiscent fruit with a more or less succulent and well-developed sarcocarp and an indurated endocarp. Drupes are superior when free from the calyx, as in prune; inferior when they possess an adherent calyx, as in pimenta. Drupes are also spoken of as "dry" when the sarcocarp is less succulent, as in rhus glabra, or when they are collected unripe, as in pepper and cubeb. The fruits of the raspberry and blackberry consist of a collection of little drupes, the whole being known as an **etærio.** In the blackberry the drupelets cohere with the fleshy receptacle, while in the raspberry the drupelets cohere with one another and are separable from the receptacle.

A **Follicle** is a dry dehiscent fruit which consists of one or more separate carpels, the dehiscence being usually along the ventral suture: in *Delphinium* the carpels are single; in aconite there are from three to five carpels, and in illicium from seven to eight; in magnolia the carpels are numerous, more or less succulent and dehisce along the dorsal suture.

A **Galbalus** is a berry-like fruit, formed by the coalescence of fleshy, open scales, as in juniper.

A **Hesperidium** is a fleshy, indehiscent, superior fruit, in which the pericarp is more or less coriaceous, and from the inner walls of which secretion hairs develop, which contain sugar and an acid cell sap, these constituting the fleshy portion in which the seeds are imbedded, as in orange and lemon.

A **Legume** is an elongated, monocarpellary, usually dry, dehiscent fruit, in which dehiscence takes place along both sutures, the carpel thus dividing into two halves, known as valves, as in the pea. In some cases legumes are jointed or articulated and indehiscent, breaking up at maturity into a number of parts which are dispersed in much the same manner as samara-like fruits, as in *Meibomia*. Legumes may be not only indehiscent but fleshy, as in cassia fistula.

A **Nut** is an achene-like fruit, the pericarp of which is more or less indurated. Nuts are sometimes subtended (as in acorns) or inclosed by (as in chestnuts) a kind of involucre, forming what is technically known as a cupule; and a fruit consisting of a nut and cupule is known as a **Glans**. The achene-like fruit of the Labiatæ is spoken of as a Nutlet.

A **Pepo** is an inferior berry, in which the placentæ have become developed into succulent layers, as in the watermelon and cucumber.

A **Pod** is a general term used to designate all dry, dehiscent, apocarpous or syncarpous fruits, as capsules, follicles and legumes.

A **Pome** is an indehiscent, inferior, fleshy, syncarpous fruit, as in the apple. The carpels constitute the core, and the fleshy part is developed from the combined receptacle and basal portion of calyx, corolla and stamens.

A **Samara** is a winged achene-like fruit; the winged appendage may be at the apex, as in white ash, or around the edge, as in elm. Two samaras may be united into one fruit, which is called a "double samara."

A **Sorosis** is a fleshy fruit resulting from the aggregation of the carpels of several flowers, as in mulberry and pineapple.

A **Strobile** or cone is a scaly fruit, at the base of each scale of which there is either a seed, as in the Coniferæ, or an achene-like product, as in the hop.

A **Syconium** consists of a succulent hollow receptacle, which incloses a number of achene-like products.

An **Utricle** is an inferior achene with a thin and loose pericarp, as in chenopodium.

CLASSIFICATION OF FRUITS.

More or less artificial classifications of fruits have been made. They may be grouped either according to structure or according to their manner of protection or dispersal, the following classification being based on the structure:

- I.—From a Number of Flowers.
  - Galbalus.
  - Strobile or Cone.
  - Sorosis.
  - Syconium.
- II.—From a Single Flower.
  - A. With Two or More Pistils.
    - (a) Indehiscent.
      - *Dry.*
        - Achene.
        - Caryopsis.
        - Cremocarp.
        - Nut.
        - Samara.
        - Utricle.
      - *Fleshy.*
        - Berry.
        - Drupe.
        - Etærio.
        - Hesperidium.
        - Pepo.
        - Pome.
    - (b) Dehiscent.
      - *All Dry.*
        - Capsule.
        - Follicle.
  - B. With a Single Pistil.
    - (a) Indehiscent.
      - *All Fleshy.*
        - Drupe.
    - (b) Dehiscent.
      - *All Dry.*
        - Follicle.
        - Legume.

INNER MORPHOLOGY OF FRUITS.

The inner structure of fruits is quite variable and it is difficult to treat of this in a general way. In the simplest fruits there are three distinct layers, as in the capsule of cardamom, in which there is an outer epidermis of isodiametric or polygonal cells, an inner epidermis of more or less obliterated and elongated cells, between which is a thin-walled parenchyma traversed by a number of fibrovascular bundles.

In some cases the outer epidermis contains numerous stomata, as in poppy capsules, or is developed into hairs and other outgrowths or appendages, as in anise, arnica, rhus glabra and raspberry.

The inner epidermis may also contain stomata, as in

the poppy, or be developed into hairs, as in vanilla and orange, or be more or less obliterated, as in achene-like fruits, or be modified to sclerenchymatous elements, as in drupes.

The middle layer, which is composed of parenchyma, may contain organized cell-contents, starch, sugars, calcium oxalate, coloring principles, alkaloids and other principles, and it may also have oil-secretion cells, as in cubeb, or oil-secretion reservoirs, as in orange and the fruits of the Umbelliferæ, in the latter of which they are known as **vittæ**; milk vessels some times occur, as in poppy; a collenchymatous layer is sometimes developed beneath the epidermis, as in capsicum; in some cases sclerenchymatous cells may be present, as in pimenta; and in still other instances the entire pericarp may be made up of stone cells.

III. THE SEED.

The seed may be defined as the fertilized and developed ovule. The seeds of different fruits vary in number as well as in size and shape. In form they correspond to the ovules; in size they vary from about 1 millimeter, as in the poppy, to 10 or 15 centimeters in diameter, as in the cocoanut palm. Seldom are all of the ovules of the pistil fertilized, hence the number of seeds is usually less than the number of ovules.

After the fertilization of the egg-cell certain changes take place in the embryo sac: at one end the developing embryo becomes attached to the wall by a stalk; the nuclei, lying in a mass of protoplasm around the wall, divide and re-divide; the large vacuole in the center becomes filled with a watery or milky fluid, and later the nuclei, with portions of the protoplasm, may be inclosed by a cellulose wall and become permanent cells, in which the embryo is embedded.

Likewise in the nucellus, changes are also taking place; the cells are found to be dividing, and storing starch, oil, aleurone and other food materials, like the cells of the embryo sac. The reserve cells of the nucellus constitute the **perisperm**, while those formed in the embryo sac make up the **endosperm.** Usually the endosperm of seeds is prominently developed while the perisperm occurs as a thin layer; in cardamom, however, the endosperm and perisperm are both well developed. In some instances the embryo may not fill the embryo sac, as in cocoanut, and some times, as in the almond, both of the reserve layers are consumed in the development of the embryo.

The perisperm and endosperm are sometimes spoken of as constituting the albumen of the seed, but as the cells comprised in these layers contain not only organized contents and aleurone grains, but starches, oils and other substances, the term is misleading. On this basis, seeds containing either endosperm or perisperm, or both, have been designated as albuminous, but on account of these layers containing larger proportions of other substances than proteids it would be better to speak of them as **reserve layers.**

While these changes in the nucellus and embryo sac have been going on there have been equally great changes in the coats of the ovules, which later constitute the seed-coats. In the seed the two coats are generally readily distinguishable: the inner, as in ricinus, pepo, etc., is thin, light in color and of a delicate structure, and is known as the **tegmen** or endopleura; the outer is more or less thickened, of a darker color and firmer in structure, and is known as the **testa**, spermoderm or episperm. In some instances the perisperm, or both perisperm and endosperm, may be reduced to a thin layer and be considered as form-

ing a part of the seed-coat, as in mustard. In other cases the two coats are so closely united that they are not easily distinguished, as in stramonium.

The terms used in describing the kinds of ovules, as orthotropous, anatropous, campylotropous, etc., are retained in the description of the seeds; and in describing the different parts of the seed some of the terms which were applied to the ovule are also retained, as chalaza and raphe; the seed when ripe usually becomes detached from its stalk and the scar remaing is called the **hilum**; that part of the seed corresponding to the foramen of the ovule is more or less closed and is known as the **micropyle**; the embryo develops in such a way that the tip of the root always points in the direction of the micropyle.

Externally, the seed-coats vary considerably; they may be nearly smooth, as in ricinus; finely pitted, as in the mustards; prominently reticulate, as in staphisagria; hairy, as in cotton, or winged, as in the seeds of the catalpa. There are also a number of other appendages, these having received special names: the wart-like development at the micropyle or hilum of some seeds, as in castor-bean and violet, is known as a **caruncle**; in the case of sanguinaria, a wing-like development extends along the raphe, and this is known as the **strophiole**; in some cases the appendage may completely envelop the seed, when it is termed an **arillus**; when such an envelope arises at or near the micropyle of the seed, as the mace in nutmeg, it is known as a "false arillus," or **arillode**.

INNER MORPHOLOGY OF THE SEED.

The seed-coat usually consists of from two to six layers of cells: (1) an outer layer or so-called epidermis, (2) a layer of sclerenchymatous cells or stone

cells, (3) a pigment layer, (4) one or two rows of parenchymatous cells, (5) a row of more or less obliterated parenchyma cells.

The **epidermal cells** vary considerably in different species, both as regards the form of the cells and the composition of the walls; the cells may be more or less isodiametric in cross section, as in cardamom; elliptical, as in almond; palisade-like, as in *Abrus precatorius*, or more or less irregular, as in *Delphinium*. While the outer and side walls are usually thickened, in hyoscyamus it is the inner and side walls which are thickened, the outer wall remaining thin. The outer wall may be in part modified to mucilage, as in mustard and flaxseed; or to non-secreting hairs which consist either of cellulose, as in cotton, or lignocellulose, as in nux vomica.

The **perisperm** and **endosperm** consist chiefly of parenchyma cells, which contain, besides the organized contents, starch, as in physostigma; oil, as in strophanthus; aleurone grains, as in ricinus; glucosides, as in almond; alkaloids, as in stramonium. The walls are usually thin, but may in some instances be considerably thickened, as in coffee, colchicum and nux vomica.

In the fully developed **embryo** three distinct parts may be differentiated: (1) the **cotyledons**; (2) the part below the cotyledons, known as the **hypocotyl**, the apical portion of which constitutes the root-like portion or **radicle**; (3) the part above the cotyledons, known as the **epicotyl**, the apex of which consists of a more or less developed bud spoken of as a **plumule.**

The **position of the embryo** in the seed varies somewhat: in most seeds it lies in the center, as in strophanthus and linum; it may, however, be excentral, as in colchicum and nutmeg. The cotyledons are usually

situated above the hypocotyl, but in the Cruciferae, either their edges lie against the hypocotyl, as in the mustards, when they are said to be **accumbent** or conduplicate, or they lie so that the back of one is against the hypocotyl, as in *Lepidium*, which position is known as **incumbent**.

The embryo consists chiefly of parenchyma cells with a few fibrovascular bundles; the cotyledons may be thin and leaf-like, as in ricinus and nux vomica, or thick and fleshy, as in almond and cola; the hypocotyl is usually small, but in the Umbelliferae it is as large as the cotyledons.

PART II.

PHARMACOGNOSY.

CHAPTER I: CRUDE DRUGS.

A. INTRODUCTORY.

Pharmacognosy is a term derived from two Greek words which, together, mean a knowledge of drugs. While there has been little or no attempt to define what constitutes pharmacognosy, it is usually limited to the study of drugs of vegetable origin.

The origin of the word **drug** is more or less obscure, but it is now applied to any crude substance which may be employed in medicine, whether of vegetable, animal or mineral origin.

The **natural origin** is the scientific name of either the plant or animal yielding the drug. In the case of vegetable drugs the natural origin is spoken of as the **botanical origin.** A vegetable drug usually represents some special part of the plant, but in some instances the entire plant is employed, as chirata.

The **habitat** of medicinal plants is the region where they grow. Sometimes this term is applied erroneou-ly to the drugs themselves. Neither the scientific name of the plant nor the commercial name of the drug may be relied upon as indicating the true habitat of medicinal plants as, for example, *Spigelia Marilandica*—the specific name of which indicates that it is found in Maryland—is only occasionally met with in that State. In other cases plants are common to a much larger territory than the specific name would indicate, as *Prunus Virginiana.* The geographical names associated with drugs frequently apply to the ports of

export rather than to the habitat of the plant yielding the drug as, for example, Para sarsaparilla, which is obtained from a plant growing in the upper Amazon region, is shipped to Para from whence it is exported.

Plant Names.—Prior to the time of Linné the names of both plants and animals were made up of many words; since his time two or, at the most, three words, in conjunction with the name of the author, constitute the scientific name. The first in order is the Generic name, or name of the genus; the second is the Specific name, or name of the species, and the third is the Varietal name, or name of the variety, and is frequently used in connection with the abbreviation *var.*, the name of the author following this as well as the specific name.

As illustrating these the following examples may be given:

Generic Name.	Specific Name.	Author's Name.	Varietal Name.	Author's Name.
Gentiana	lutea	Linné		
Mentha	piperita	Linné		
Mentha	piperita	Linné	var. piperascens	Malinvaud

It is thus seen that varieties, providing they exist, are included under species, species make up genera, genera are grouped into families and families constitute natural orders, these in turn being united to form still more general classes as series, sub-classes, and sub-kingdoms.

The official or **pharmacopœial titles** of vegetable drugs are derived from either the generic name of the plant (as gelsemium) or the specific name (as ipecacuanha), or they may include both the generic and specific names (as viburnum prunifolium), or they may be derived from other sources (as opium and sarsaparilla).

In addition to the botanical names of plants and

the pharmacopœial titles of drugs, a number of vernacular names and synonyms are employed in describing them.

The official or **pharmacopœial definition** of drugs is given in the leading paragraph of the different pharmacopœias under each drug and includes the botanical origin as well as the name of the part of the plant yielding the drug; and in some cases other special features or requirements are given, as the habitat of the plant yielding the drug, the time of collection, mode of preservation, etc.

Plants which yield drugs may grow wild, as is most usually the case, or they may be cultivated, as those yielding anthemis, cannabis indica and the solanaceous leaves. Plants growing in their native countries are said to be **indigenous** to those regions, as *Stillingia sylvatica* of the Southern United States; *Aconitum Napellus*, of the mountainous regions of Europe, etc. Plants are said to be **naturalized** when they grow in a foreign land or in another locality than their native home. Some of these may have been distributed by natural agencies, or they may have escaped from cultivation, or they may have been introduced with the seeds of cultivated plants or with the ballast of ships.

The term **commercial origin** applies solely to the drugs themselves, and indicates their commercial source; that is, either the country where the plant yielding the drug is grown, or the port from which the drug is sent into the marts of the world. English hyoscyamus leaves are gathered from plants grown in England; Canton rhubarb is the product of plants grown in various parts of China, but shipped by way of Canton.

The time of the **collection of vegetable drugs** is of prime importance, and while we may not be able to make

extended generalizations, still, the following general rules for the collection of various drugs may be given:

(1) Roots, rhizomes and barks should be collected immediately before the vegetative life-processes begin (in the spring) or immediately after the vegetative processes cease (usually in the fall).

(2) Leaves should be collected when the CO_2 assimilation process is most active; usually about the time of development of the flowers and before mature development of fruit and seed.

(3) Flowers should be collected prior to or just about the time of pollination.

(4) Fruits should be collected near the ripening period (*i.e.*, full grown but unripe).

(5) Seeds should be collected when fully matured.

The preservation of vegetable drugs is likewise deserving of careful consideration, and attention should be given to the influence of temperature, moisture, the attacks of insects, and also air and light. The temperature of the room or part of the store devoted to the storage of dry drugs should not be more than about 70° F., and nearly uniform throughout the year.

Drugs containing volatile principles require to be kept in air-tight containers, as the labiate and composite herbs and wild-cherry bark. Air-tight tin cans are probably the most economical and satisfactory containers for the purpose, and it has been suggested to paint the edges of the cans with melted beeswax. Drugs are sometimes stored in wooden boxes or in drawers. This method is objectionable, not only because they are more liable to deteriorate, but because the odors are communicable from one to the other. The storage of drugs in parcels is the worst form of preservation, particularly, as is usually the case, when the different parcels are stored together.

Those drugs that are difficult to dry, as the inulin-containing drugs, should be kept in containers having a number of apertures, to allow evaporation to take place. Unless provision of this kind is made, molding of the drug may develop.

The preservation of drugs against the attacks of insects is, unfortunately, generally overlooked. Most drugs are subject to their depredations, and are usually attacked by the insects in the larval stage. These insects belong chiefly to the Lepidoptera, Coleoptera and Diptera. The Lepidoptera are the most destructive, and include *Tinea zea,* or cornmeal moth, which, during its larval (the caterpillar or grub) stage, is known to attack aconite, capsicum, ergot, lappa, linseed, rhubarb, taraxacum and many other drugs. Among the Coleoptera may be mentioned various members of the *Ptinedæ,* as *Ptinus brunneus, Anobium paniceum* and *Lasioderma serricorne,* which attack the spices chiefly, as capsicum, cinnamon and pimenta. Chief among the Diptera is *Trypeta arnicivora,* which is sometimes found in arnica flowers.

For the destruction of these insects and prevention of their attacks, a number of substances and methods have been employed, the simplest method of all being to expose the drug to a temperature of about 100° C. This method is, however, open to objection, as there is liability either to decomposition or loss of active principle. A weak solution of carbolic acid has also been suggested, but, of course, this is also objectionable. Camphor and tar-camphor have been employed, but it is doubtful if they should be used, unless in the case of animal drugs. In some instances, as with nutmeg and ginger, the drug is sprinkled in the drying-room, and when packed for market, with quicklime. Benzin and carbon disulphide have been proposed, but these

are of a disagreeable odor as well as inflammable. Ether has been suggested, but it is very volatile and inflammable. The use of formaldehyde should proceed slowly until it is certain that it has no harmful effects, especially when used in the preservation of herbs used for teas for children; and orris root, which is used for teething infants. The use of chloroform as a preservative has been sanctioned by the U.S.P. in the case of ergot, and is probably the best preservative that has been proposed.

Commercial Forms of Drugs.—Vegetable drugs are brought into the market in various forms: they may be crude; that is more or less entire, or in a powdered condition. Crude drugs may be nearly entire as seeds, flowers, fruits, leaves, and some roots and rhizomes; or they may be cut or sliced, as in woods, barks and many roots and a few rhizomes. They may be more or less matted together, as in chondrus and the solanaceous leaves; or they may be pressed together by means of hydraulic pressure, giving the so-called pressed drugs; or they are first powdered and then molded into forms, as "rhubarb fingers." In some cases the periderm is removed, as in a number of roots, rhizomes and barks.

The quality of vegetable drugs is injured by a number of conditions, of which the following may be mentioned: (1) lack of knowledge or want of care in collecting them; (2) carelessness in drying and caring for them; (3) insufficient care in garbling and preparing them for the market; (4) inattention in preserving them and storing them; (5) accidental admixture in the store, and (6) adulteration and substitution.

The influence which the **time of collection** has on the quality of vegetable drugs may be best shown by a few illustrations. It is well known that when the fruits of

conium are green they will yield over 3 per cent. of coniine, but when they become yellow the alkaloid diminishes rapidly in quantity, and, therefore, much of the commercial drug will not yield 1 per cent. of coniine. The same thing may be said of santonica: when the flower heads are unexpanded they will yield over 3 per cent. of santonin, but just so soon as the flower matures there is a rapid disappearance of the anthelmintic principle. Dealers in insect flowers (*Flores pyrethri*) know that those gathered when the flowers are closed produce the finest and most powerful insect powder, and it is worth nearly twice as much as that made from the half-closed or open flowers. It may be that the variation in quality of some of the commercial aconite is due to improper drying, or to the extraction of the active principles; still, there is no doubt but that much of the trouble with this drug is due to the variation in the time of collection in different countries, as well as to its being collected from different species.

Another factor influencing the quality of vegetable drugs is carelessness in drying them and caring for them after they are gathered. In some cases the Pharmacopœia specifies that the drug shall be kept a certain length of time before being used, as in the case of frangula. A similar specification should be made in regard to rhamnus purshiana; but since the results of the changes on keeping are now ascertained, and since a similar effect may be obtained by heating the bark at 100° C. for forty-eight hours, this specification seems no longer necessary.

In some drugs a sort of ripening process takes place in the drying, as in tobacco and vanilla. In still others a marked deterioration takes place if they are placed in heaps and allowed to ferment, as with lavender and most other drugs yielding essential oils.

Furthermore, in the preparation of oil of peppermint, the yield of oil is greater and the quality better if the plants are allowed to dry and are distilled immediately or soon after drying.

Quite a number of drugs are not infrequently observed in commerce in a moldy condition, as taraxacum, veratrum, maranta, aconite, etc. The question as to what influence this mold has on the quality of the drug has not been cleared up.

Another cause of inferiority of vegetable drugs is lack of sufficient care in **garbling.** This applies to a number of drugs as leaves, where there may be a large number of stems and roots; rhizomes and tubers, where the proportion of stem-remnants may be excessive; or in other cases, as cypripedium and hydrastis, where roots, which contain much less of the active principle, have been found to the extent of 50 per cent.

A fourth quality influencing the quality of drugs is the **manner of preservation.** While it is generally conceded that most drugs deteriorate in keeping, still this depends largely upon the manner of their preservation. Thus, the Pharmacopœia limits the time of keeping of ergot and states how it shall be preserved; yet a number of writers call attention to the fact that, if properly prepared and preserved, the time of keeping may be very much extended. In order to preserve ergot, Grover proposed the removal of the oil, and Moss found the drug thus treated to retain its therapeutic value for six and a half years. Zanon suggests placing the drug in alternate layers with sand and keeping it in a closely sealed jar. Others grind the fresh ergot and preserve with chloroform in paraffin paper, while still others first extract the oil with alcohol or ether.

Accidental admixture in the store or warehouse

depends upon the care of the individual, and need not receive attention here.

The adulterations, substitutions and sophistications will be considered under the respective drugs.

The Valuation of Drugs.—In the identification of vegetable drugs certain characteristics are taken into account, such as color, odor, general appearance, structure, texture, etc., these at the same time indicating in a greater or less degree the qualitative value of the drug. While these characteristics may enable the expert to detect very slight variations in quality, and to estimate approximately the value of a given drug, still the true value is based upon the amount of the medicinal principles or so-called active constituents. The methods employed in the valuation of drugs may be grouped as follows: (1) Chemical, (2) Physical, (3) Microscopical, and (4) Biological.

(1) Chemical methods are more generally employed and usually involve the isolation and estimation of the active principles.

(2) Physical methods involve such processes as the determination of specific gravity of the drug, as of jalap, or the determination of the elasticity or measurement of the fibers, as of cotton, and still other special methods which apply to individual drugs, giving indirectly their valuation.

(3) Microscopical methods of valuation may oftentimes be employed when other methods fail, as, for example, when foreign starches are added to starchy products, as in the cereals and spices. Microchemical reactions may also be depended upon in some instances to indicate the value of a drug, as in strophanthus where the value of the drug depends directly upon the number of seeds giving a green coloration with sulphuric acid.

(4) Biological methods involve the consideration of the effects of drugs upon animals or plants. They may be conveniently grouped as follows: I. Effect or influence upon animals; (*a*) depending upon the perceptions or senses of the experimenter or tester; (*b*) depending upon the physiological or pathological effects upon lower animals, as insects, frogs, rabbits, guinea pigs, etc., and even man. II. The effect or influence upon plants, depending upon the effects of extracts of drugs, or solutions of their active principles upon germinating plants, this being estimated by the amount of growth of the root of the plant placed in the solution, in a given time, or by the changes in the tissues.

B. DRUGS DERIVED FROM FLOWERING PLANTS.

I. SEEDS.

From an economical point of view seeds, both as regards their medicinal properties and the food products which they yield, constitute a most important group. They should, as a rule, be collected when they are ripe and carefully preserved against the attacks of insects and changes of various kinds, as those incident to germination. They may, or may not, be dried before using.

For convenience in their study, as well as their recognition, the medicinal seeds may be classified as follows:

I. ENTIRE SEEDS.

I. *Not more than* 5–6 *mm. long.*

1. With an appendage (*caruncle*):

a. Ovoid or irregularly globular, dark brown, . . . Colchici semen

2. Without an appendage:

A. Anatropous.

a. Ovate, flattened, smooth . . . . Linum

b. Triangular or quadrangular, reticulate . . Staphisagria

B. Campylotropous.
- *a.* Globular.
  - Yellowish brown . . . . Sinapis alba
  - Reddish brown . . . . Sinapis nigra
- *b.* Reniform, bluish black . . . . . . Stramonii semen

II. *Between* 10–20 *mm. long.*
- Whitish, smooth . . . . Pep
- Yellowish green or light brown, hairy . . . Strophanthus

III. *Between* 20–30 *mm. long.*
1. More or less flattened:
   - *a.* Ovate or oblong-lanceolate.
     - Bitter . . . . Amygdala amara
     - Sweet . . . . Amygdala dulcis
   - *b.* Plano-convex or 3 to 6-sided . . . . Cola
   - *c.* Orbicular, hairy . . . . Nux vomica
   - *d.* Reniform, brownish red . . . . Physostigma
2. Not flattened:
   - Ellipsoidal . . . . Myristica

II. PRODUCTS OF OR PARTS OF SEEDS.

Hairs . . . . Gossypium
A paste of the crushed seeds . . . . Guarana
The arillode of Myristica . . . . Macis

COLCHICI SEMEN—(Colchicum Seed).

The dried, ripe seeds of *Colchicum autumnale* (Fam. Liliaceæ), a perennial bulbous plant, native of and growing in moist meadows and pastures in Southern and Middle Europe and Northern Africa. The commercial supplies come chiefly from England and Germany.

Description.—Hemi-anatropous, ovoid or irregularly globular, more or less beaked, with an easily detachable strophiole, 2 to 3 mm. in diameter; externally dark brown, becoming darker with age, minutely pitted, the epidermis detached in irregular patches in older seeds; frequently agglutinated when fresh, due to the presence of a saccharine exudation; very hard when dry, tough when damp; internally whitish, endo-

sperm hard, embryo 0·5 mm. long and situated at end opposite strophiole; nearly inodorous; taste feeble, bitter and somewhat acrid.

Constituents.—Proteids; fixed oil about 6 per cent.; a tannin-like substance in the seed-coat; starch grains in the caruncle; an alkaloid colchicine about 0·5 per cent.; a resinous principle colchicoresin; ash about 2·5 per cent.

LINUM (Linseed or Flaxseed).

The seed of *Linum usitatissimum* (Fam. Linaceæ), an annual, which is cultivated in nearly all temperate and tropical regions, either for the fiber (flax) or seed.

Description.—Anatropous, ovate or oblong-lanceolate, flattened, somewhat less rounded on one side and on one margin, apex acute or beaked, chalazal end rounded, plano-convex in transverse section, 4 to 5 mm. long, 2 to 2·5 mm. broad, 0·5 to 0·75 mm. thick; externally light brown, very smooth and glossy, the raphe extending as a distinct, light-yellow ridge along one edge, outer wall of epidermal cells transparent, mucilaginous and swelling in water; easily cut; internally, endosperm white, adhering to the seed-coat, embryo light green, straight, 3 to 4 mm. long, 1 to 2 mm. broad, cotyledons plano-convex; odor slight; taste mucilaginous and slightly unpleasant.

Constituents.—Fixed oil 30 to 40 per cent.; proteids about 25 per cent.; mucilage in outer walls of the epidermal cells, 6 to 15 per cent; ash 1 to 4 per cent.

Ground flaxseed (flaxseed meal or crushed linseed) is not infrequently deficient in oil on account of its being admixed with "oil-cake" or "cake-meal" (the latter being the residue left after expressing about 20 to 30 per cent. of the oil naturally occuring in the crushed linseed), which deficiency is sometimes made

up by the addition of mineral oils. Ground flaxseed sometimes contains fragments of the cereals, rye and wheat, which is partly due to the fact that these cereals grow in with the flax, and partly because it is sometimes shipped in meal or flour sacks.

STAPHISAGRIA (Stavesacre).

The ripe seed of *Delphinium Staphisagria* (Fam. Ranunculaceæ), an annual or biennial native of Southern Europe and Asia Minor, and cultivated in Austria (Trieste), Italy and Southern France, from which latter countries the commercial supplies are obtained.

Description.—Anatropous, irregularly triangular or obscurely tetrahedral, one side convex, the others plane, the micropylar end acute or obtuse, 5 to 6 mm. long, 3 to 6 mm. broad; externally dark brown, becoming lighter and duller with age, more or less uniformly reticulate, the pits being about 0·5 mm. in diameter, raphe forming a more or less distinct ridge on the largest of the plane surfaces or on the edge of two united sides, epidermis modified to distinct papillæ; inner seed-coat yellowish brown, adhering to the endosperm when moistened, the latter white or yellowish and inclosing, at the pointed end, a small straight embryo 1 mm. long and with a relatively large hypocotyl; slightly odorous; taste of endosperm intensely bitter and acrid.

Constituents.—Alkaloids, of which there are five, about 1 per cent.: these are delphinine and delphisine, which are crystalline; delphinoidine and staphisagrine, which are amorphous, and staphisagroine, which differs from the others in that it is insoluble in chloroform. The seeds also contain, besides proteids, about 25 per cent. of a fixed oil, and yield about 8 or 9 per cent. of ash.

Allied Plants.—A number of other species of *Delphinium* have been investigated and found to have poisonous properties: the seeds of *Delphinium consolida* resemble stavesacre, but are only about one-fifth the size.

SINAPIS ALBA (White Mustard).

The dried, ripe seeds of *Sinapis alba* (Fam. Cruciferæ), an annual native of Europe, and naturalized and extensively cultivated in many countries. The commercial supply of the drug is obtained from plants grown in England, Germany, Holland and Italy.

Description.—Campylotropous, irregularly spherical, somewhat compressed, 1 to 2 mm. in diameter; externally yellowish brown, seed-coat membranaceous, and minutely pitted, marked on one side by a distinct ridge and two parallel furrows formed by the hypocotyl and cotyledons; internally without a reserve layer, light yellow, hypocotyl curved, cotyledons conduplicate; inodorous; taste pungent and acrid.

Constituents.—Fixed oil about 20 per cent.; mucilage in the outer wall of the epidermal cells about 15 per cent.; proteids about 30 per cent.; a glucoside sinalbin and a ferment myrosin, which yield on interaction a yellowish non-volatile oil (acrinyl sulphocyanide) which is pungent to the taste, but owing to its non-volatile character, does not affect the eyes or nose.

Adulterants.—While the whole mustard is seldom, if ever, adulterated, ground mustard may contain wheat middlings, or shorts, and occasionally rice or pea flour; when these cereals are employed, turmeric is also added to bring up the color, which latter may be detected by its solubility in water, alcohol, ether and volatile oils and by its becoming brown with alkalies.

SINAPIS NIGRA (Black Mustard).

The dried, ripe seeds of *Brassica nigra* (Fam. Cruciferæ), an annual occurring much the same as *Sinapis alba*, and differing from it chiefly in peculiarities of the pod and color of the seed.

Description.—Campylotropous, ellipsoidal or irregularly spherical, 1 to 1·5 mm. in diameter; externally brownish-red, seed-coat membranaceous, finely pitted, hilum whitish, forming a conical projection, micropyle occurring as a slight depression; internally without a reserve layer, hypocotyl curved, cotyledons conduplicate; inodorous; taste pungent and acrid.

Constituents.—Black mustard contains the same constituents as white mustard, save that it contains less of the ferment, myrosin, and the sinalbin is replaced by the glucoside, sinigrin (potassium myronate), which yields on interaction with the myrosin a light yellowish volatile oil (allyl isosulphocyanide or volatile oil of mustard), which has an acrid, burning taste, pungent odor, and also affects the eyes.

Allied Products.—Of the seeds of the other Cruciferæ which somewhat resemble black mustard, the following may be mentioned: the seeds of field mustard or *Sinapis arvensis*, which are almost black and perfectly smooth; the seeds of sarepta mustard, or *Sinapis juncea*, which are smaller, dark brown and nearly smooth; rape or colza seeds yielded by *Brassica Napus*, which are larger and of a bluish-black color; turnip seeds yielded by *Brassica campestris*, which are somewhat larger but less acrid.

STRAMONII SEMEN (Stramonium Seed).

The ripe seeds of *Datura Stramonium* (Fam. Solanaceæ), an annual native probably of the regions of the Black and Caspian Seas and growing wild in

waste places in temperate and sub-tropical regions. The commercial supplies are largely obtained from France, Germany and Hungary.

Description.—Campylotropous, reniform, flattened, about 3 to 4 mm. long, 2 to 3 mm. broad; externally bluish black, minutely reticulate; hard but easily cut lengthwise along the edge; internally whitish, the reserve layer occupying about one-half the seed, the embryo crook-shaped; odor slight, disagreeable when bruised; taste bitter.

Constituents.—Fixed oil about 25 per cent.; proteids; alkaloids about 0·4 per cent. and consisting principally of hyoscyamine together with a small proportion of atropine and scopolamine (hyoscine); ash 2 to 3 per cent.

PEPO (Pumpkin Seed).

The ripe seeds of *Cucurbita Pepo* (Fam. Cucurbitaceæ), a procumbent herb native of Tropical America and possibly Tropical Asia, and long cultivated in tropical and temperate zones as a vegetable and cattle food. The seeds of other species of Cucurbita are also used in medicine; in Italy *C. maxima* and in the West Indies *C. occidentalis* are the sources of the drug.

Description.—Anatropous, broadly elliptical, acute, acuminate or truncate, flattened, about 20 mm. long, 10 mm. broad, about 2 mm. thick; externally white or light yellow, very smooth or somewhat rough from adhering fruit pulp, marked by a shallow groove or slight ridge parallel to and within 1 mm. of the margin; raphe not conspicuous, hilum characterized by a minute depression; seed-coat consisting of two distinct layers—the outer white and coriaceous and the inner dark green and membranaceous; embryo white, straight, consisting of a small conical hypocotyl and

two plano-convex cotyledons; slightly odorous when contused; taste bland.

Constituents.—Fixed oil about 40 per cent.; starch about 30 per cent.; proteids; an aromatic principle; an acrid resin, a glucoside (cucurbitin) and possibly an alkaloid (cucurbitine), the presence of the last two principles needing confirmation; ash 3 to 4 per cent.

Allied Plants.—The seeds of other members of the Cucurbitaceæ are also employed in medicine; they include the seeds of watermelon (*Citrullus vulgaris*), cucumber (*Cucumis sativus*), muskmelon (*Cucumis melo*) and lagenaria (*Cucurbita Lagenaria*).

STROPHANTHUS.

The ripe seeds of *Strophanthus Kombe* Oliver and *Strophanthus hispidus* De Candolle (Fam. Apocynaceæ), twining shrubs found in Senegambia, Upper Guinea and other parts of Western Africa (*S. hispidus*), and the Kombe country and other parts of Eastern Africa (*S. Kombe*). The plumose awns at the apex of the seeds are usually removed before exportation.

Description.—Hemi-anatropous, oblong-lanceolate or spatulate, acute or acuminate, unevenly flattened and in transverse section deltoid or plano-convex, 8 to 15 mm. long, 3 to 5 mm. broad, 1 to 1·5 mm. thick (*S. Kombe* being the larger); externally yellowish green (*S. Kombe*), or light brown (*S. hispidus*), covered with long hairs giving a silky appearance to the seed (*S. hispidus* being less hairy), the raphe extending as a distinct ridge from the hilum about half the length of the seed; fracture short; internally whitish, endosperm about 0·2 mm. thick, embryo 6 to 12 mm. long and 1 to 2 mm. broad, cotyledons plano-convex, about 1 mm. thick, hypocotyl conical, 2 mm. long; inodorous except when broken; taste very bitter.

When treated with sulphuric acid (sp. gr. 1·73) the endosperm, in about 65 per cent. of the seeds, becomes green; the cotyledons red or purple and finally green, in some instances.

CONSTITUENTS.—Strophanthin, a crystalline principle occurring chiefly in the endosperm and varying from 0·65 (*S. hispidus*) to 0·95 per cent. (*S. Kombe*), or, as reported by some investigators, occasionally as high as 3 per cent; strophanthin is colored greenish with sulphuric acid, and yields on decomposition a crystalline body called strophanthidin; the other constituents are kombic acid and about 30 per cent. of a fixed oil.

ALLIED PLANTS.—The seeds of a number of other species and varieties of *Strophanthus* find their way into the market, but these are usually more or less deficient in strophanthin and do not give a greenish color with sulphuric acid.

ADULTERATION.—The seeds of *Kicksia Africana* (Fam. Apocynaceæ) have been found admixed with strophanthus, but are distinguished from it by being glabrous and not giving the strophanthin reaction.

AMYGDALA AMARA (Bitter Almond).

The ripe seed of *Prunus Amygdalus*, var. *amara* (Fam. Rosaceæ), a tree native of Asia Minor, Persia and Syria, and cultivated and naturalized in tropical as well as warm temperate regions. The commercial product is obtained mostly from Sicily, Southern France, Southern Italy, and Northern Africa. In commercial almonds the yellowish, more or less porous, fibrous and brittle endocarp is frequently present, and this should be removed.

DESCRIPTION.—Anatropous, ovate or oblong-lanceolate, flattened, more rounded on one margin, apex acute or beaked, chalazal end rounded or obliquely

truncate, 20 to 30 mm. long, 11 to 17 mm. broad, 7 to 9 mm. thick; externally light brown, with numerous parallel veins extending from the chalaza to the micropyle, outer walls of epidermal cells modified to distinct papillæ, seed-coat thin, membranaceous, easily removed on soaking the seed in water, the raphe extending on the more rounded edge as a more or less distinct ridge from the hilum to or near the chalaza; fracture short; internally without reserve layers, embryo straight, whitish, hypocotyl conical, 2 to 3 mm. long, cotyledons plano-convex, sometimes slightly unequal, plumule 1 mm. long; odorless, except on treatment with water, when an odor of hydrocyanic acid is emitted, or of benzaldehyde when old; taste bitter.

CONSTITUENTS.—Fixed oil 45 per cent.; proteids 25 per cent.; a glucoside, amygdalin, about 1·25 per cent.; and a ferment emulsin, which acts upon amygdalin, decomposing it into a volatile oil (benzaldehyde or oil of bitter almond) and hydrocyanic acid.

Amygdalin, or a similar principle, is found in the young shoots and flower-buds, as well as seeds, of apricot, peach, plum, cherry, cherry-laurel and other members of the Rosaceæ.

AMYGDALA DULCIS (Sweet Almond).

The ripe seeds of *Prunus Amygdalus*, var. *dulcis* (Fam. Rosaceæ) a tree like the bitter almond but more extensively cultivated. The commercial supply is obtained from Northern Africa, Southern France, Italy and Spain, the choicest seeds being imported from Malaga and known as "Jordan Almonds."

DESCRIPTION.—Closely resembling the Bitter Almond but giving no odor of hydrocyanic acid when treated with water, or of benzaldehyde when old; taste bland and sweet.

Constituents.—Resembling bitter almond, but containing slightly more fixed oil, and being free from amygdalin.

COLA (Kola).

The kernel of the seed of *Cola acuminata* (Fam. Sterculiaceæ), a tree native of Tropical Western Africa and cultivated in nearly all other tropical countries. The commercial supplies come principally from Western Africa and the West Indies. The kernels are used in either a fresh condition or the cotyledons are separated and dried.

Description.—Anatropous, plano-convex, polygonal, three to six-sided, 18 to 35 mm. long and 5 to 20 mm. in diameter; externally yellowish or yellowish red when fresh, but becoming darker with age and on drying, with a shallow furrow demarcating the line separating the two cotyledons, micropyle forming a distinct cleft at one end, otherwise nearly smooth; easily cut when fresh but hard when dry; internally without reserve layers, cotyledons unequal and varying from two to five in number, the hypocotyl small; odor distinct; taste astringent, somewhat sweet.

Constituents.—Starch 35 to 40 per cent., the grains resembling those of potato starch but uniformly smaller; caffeine 1 to 2 per cent; theobromine 0·02 per cent; about 0·02 per cent. of a tannin which gives a greenish reaction with iron salts, and is apparently combined with the alkaloids.

Allied Plants.—The seeds of a number of other plants are said to be sometimes admixed with kola, and of these the following may be mentioned: *Cola Ballayi*, a plant growing in the Gaboon, the seeds of which contain six cotyledons and are deficient in alkaloids; *Garcinia Kola* (Fam. Guttiferæ), a tree known as "male cola" and found growing with *Cola acuminata*

in Eastern Africa and Senegal, the seeds of which contain two resins but no alkaloids.

NUX VOMICA.

The dried, ripe seeds of *Strychnos Nux vomica* (Fam. Loganiaceæ), a small tree native of the East Indies and also found growing in the forests of Ceylon, on the Malabar Coast and in Northern Australia. The fruit is a kind of berry with from three to five seeds, which are freed from the bitter pulp by washing, and dried before exportation.

Description.—Orbicular, compressed, concavo-convex, sometimes irregularly bent, margin acute or rounded, 17 to 30 mm. in diameter, 3 to 5 mm. thick; externally grayish-yellow or grayish-green, covered with long hairs giving the seed a satiny luster, and sometimes with dark-brown fragments of the fruit pulp, hilum near the center of one side, and a more or less distinct ridge resembling a raphe extending from it to the micropyle; very hard when dry, tough when damp; internally whitish, horny, endosperm in two more or less regular concavo-convex halves, embryo small, with two heart-shaped cotyledons and situated near the micropyle; inodorous; taste intensely and persistently bitter.

Constituents.—Ash 1 to 4 per cent.; igasuric acid; 1·5 to 5 per cent. of alkaloids consisting of strychnine and brucine, the former comprising from one-third to one-half of the total amount. Strychnine crystallizes in rhombic prisms and gives with concentrated sulphuric acid, in connection with potassium bichromate, a blue or violet color. Brucine forms rectangular octohedra and gives a deep-red color with nitric acid. A glucoside loganin is present in the seeds in small amount, but it is found in the pulp of the fruit to the

extent of 5 per cent. A small amount of starch is found in the fragments of adhering pulp.

Allied Plants.—The seeds of *Strychnos Ignatii*, a woody climber of the Philippine Islands, contain about the same amount of total alkaloids as nux vomica, of which one-third to two-thirds is strychnine. The seeds are irregular, somewhat oblong or ovoid, pebble-like, 20 to 30 mm. long, grayish or brownish black, more or less translucent, and nearly free from the trichrome-like fibers found in nux vomica.

PHYSOSTIGMA (Calabar Bean).

The ripe seeds of *Physostigma venenosum* (Fam. Leguminosæ), a woody climber growing in the region of the Gulf of Guinea on the western coast of Africa. The seeds are also known as "the ordeal bean of Calabar."

Description.—Anatropous, somewhat reniform or irregularly oblong or ellipsoidal, 25 to 30 mm. long, 15 to 18 mm. in diameter, 10 to 15 mm. thick, with a brownish-black groove from 1 to 2 mm. in diameter extending about half-way around the edge, containing the raphe as a narrow line, and in which is frequently found the remains of the white membranaceous funiculus, the micropyle occurring near one end of the groove as a slight depression; seed-coat brownish red, hard, thick, smooth, but somewhat rough near the groove; reserve layers wanting, embryo large, white, with short hypocotyl and two concavo-convex cotyledons; inodorous; taste starchy.

Constituents.—Starch about 45 per cent; proteids about 20 per cent.; fixed oil about 2 per cent.; ash about 3 per cent. Several alkaloids have been isolated, the most important of which is physostigmine or eserine; it occurs in the embryo and is colored red with alkalies.

Allied Plants.—The seeds of *P. cylindrosperum* have been substituted for Calabar bean; they are nearly cylindrical and are said also to contain physostigmine.

MYRISTICA (Nutmeg).

The kernel of the seed of *Myristica fragrans* (Fam. Myristicaceæ), a tree indigenous to the Molucca and neighboring islands, and now cultivated in other tropical regions, including the West Indies. The commercial supply is largely derived from the Malay Archipelago, from whence it is shipped to Amsterdam and London. The testa and arillode are removed, the latter constituting mace. With the exception of those from Penang, nutmegs are not infrequently partially coated with lime to protect them from the attacks of insects.

Description.—Ellipsoidal, 20 to 30 mm. long, 15 to 20 mm. in diameter; externally light brown, usually whitish from a dressing of lime, reticulately furrowed, at one end a white smooth projection 3 to 5 mm. in diameter, in the center of which is the micropyle, the chalaza indicated near the other end by a slight, dark depression, from which there extends a more or less distinct furrow indicating the position of the raphe; easily cut, the surface having a waxy luster, mottled by reason of the light-brown perisperm penetrating into the yellowish-brown endosperm, the shrunken embryo occurring in an irregular cavity about 4 or 5 mm. long, near the micropyle; odor and taste aromatic and pleasant.

Constituents.—Fixed oil, sometimes occurring in prismatic crystals, 25 to 40 per cent.; volatile oil 2 to 10 per cent.; proteids and starch.

Inferior nutmegs, the product of other species of *Myristica*, sometimes find their way into commerce;

they are characterized by being narrow-ellipsoidal, feebly aromatic and of a more or less disagreeable taste. False nutmegs, consisting of exhausted powdered nutmegs or defective nutmegs and mineral matter, have been found in European markets occasionally.

GOSSYPIUM PURIFICATUM (Absorbent Cotton).

The hairs of the seeds of *Gossypium herbaceum*, *Gossypium barbadense*, and other species of *Gossypium* (Fam. Malvaceæ), biennial or triennial shrubs indigenous to subtropical Asia and Africa, and cultivated in all tropical and subtropical countries. The seeds are hand-picked, freed from dust by screens or drums, and the cotton removed in the cotton-gin. It is then freed from mechanical impurities, deprived of fatty and other substances and finally bleached.

DESCRIPTION.—A white soft tufted mass, consisting of somewhat flattened, twisted and spirally striate one-celled non-secreting hairs, from 2·5 to 4·5 cm. long; inodorous and tasteless.

Absorbent cotton is soluble in ammoniacal solution of cupric oxide, yields less than 1 per cent. of ash, and on treating it with water the solution should have a neutral reaction and not give any reaction with ammonium carbonate, barium chloride, mercuric chloride or silver nitrate.

ADULTERANTS.—Various substances may be added to absorbent cotton to increase the rate of absorption of water, as chlorides of calcium, magnesium and zinc, glycerin and glucose; as loading materials, barium and calcium salts and clay are added to inferior grades of the article.

GUARANA.

A dried paste consisting of the crushed seeds of *Paullinia Cupana* (Fam. Sapindaceæ), a climbing shrub

native of Brazil and Uruguay. The commercial product is obtained from cultivated plants. The ripe seeds are deprived of the appendage or aril, crushed, made into a doughy mass with water, molded into forms and dried at a gentle heat.

Description.—Cylindrical sticks, 15 to 30 cm. long, 35 to 50 mm. in diameter; externally blackish brown, surface marked by depressions, but otherwise smooth; hard and brittle; internally light brown to reddish brown, somewhat variegated from the fragments of contused seeds; odor slight; taste astringent, bitter.

Constituents.—Caffeine 2·5 to 5 per cent.; tannin (catechu-tannic acid) about 25 per cent.; ash about 2 per cent.

MACIS (Mace).

The arillode of the seed of *Myristica fragrans* (Myristicaceæ) (see Nutmeg). According to Warburg the arillode arises in the region of the hilum before the flower opens and fertilization is effected.

Description.—In coarsely reticulate bands about 1 mm. thick, the whole having the outline of the nutmeg, the basal portion united, but with a small, irregular opening; usually in compressed, nearly entire pieces, reddish or orange-brown, somewhat translucent, brittle when dry; odor and taste aromatic.

Constituents.—An aromatic balsam 24·5 per cent.; volatile oil 8 to 16 per cent.; fixed oil and amylodextrin.

Bombay mace, or wild mace, is the product of *Myristica Malabarica;* it is distinguished from true mace in that the entire mace is narrow-ellipsoidal, the reticulalations are not so coarse, the apex is divided into numerous narrow lobes, and it is darker in color. With alkalies or sulphuric acid wild mace assumes a darker color than the true or cultivated mace does.

II. ROOTS AND RHIZOMES.

Roots and rhizomes represent those parts of plants which develop under ground, the latter having all of the characteristics of stems except in their manner of growth. Most drugs derived from roots and rhizomes possess the typical characteristics of these plant parts, the commercial products being readily distinguishable as such. There are some, however, that are more or less intermediate in character, and while commonly spoken of as roots, they are in reality modifications of the stem, at least in part, as aconite, gelsemium, glycyrrhiza and rhubarb. For this reason, and in order to facilitate their study, roots and rhizomes are here considered in one class, which is subdivided as follows: (1) True Roots; (2) Rhizomes that are root-like, at least in part; (3) True Rhizomes; (4) Corms; (5) Bulbs.

Some of the roots and rhizomes that are employed in medicine are prepared for market by removing a part of the periderm; in a general way this treatment is objectionable, particularly in the case of those drugs containing volatile principles, as these exist in greatest amount in the cortical portion, and the periderm serves to prevent the volatilization as well as deterioration of these principles.

Rhizomes are distinguished as upright, horizontal or oblique, depending upon their manner of growth, and this may be determined in the drug by placing the rhizome in such a position that the stem-scars are horizontal.

I. *Roots.*

1. Monocotyledons . . . . Sarsaparilla
2. Dicotyledons.

A. Periderm removed . . . . Althæa

B. Periderm present.

a. Roots nearly entire.
Tuber-like . . . . Jalapa
Long, thin and of a reddish color . . . . . Krameria
Fusiform, very acrid . . . . Pyrethrum
Keeled, crown knotty . . . . Senega
Fusiform, small, yellowish central wood . Taraxacum

b. Roots cut into transverse pieces.
Yellowish-green disks . . . . Calumba
Concentric fibrovascular bundles . . . . Pareira
Bark soft, spongy and finely fibrous . . . . Stillingia
Very light in weight, wood large with fibers interlacing . . . . Sumbul

c. Roots cut into longitudinal pieces.
Characteristic odor and taste . . . Belladonnæ Radix
Horny, tough, internally light brown . . . . . Lappa
Ribbon-like slices, very fibrous . . . . . Phytolacca

d. Roots more or less broken into pieces.
Bark transversely fissured and easily separable from the wood . . . . Apocynum
Somewhat tortuous, bark irregularly annulate and sometimes transversely fissured . . . . Ipecacuanha

II. *Rhizomes that are Root-like.*

A. Periderm removed.
Yellowish, fibrous, taste sweetish, Glycyrrhiza (Russian)
Reddish brown, heavy, granular . . . . Rheum

B. Periderm present.
Tuber-like . . . . Aconitum
Cylindrical, stem-like, fracture tough, wiry . Gelsemium
Annulate above, odor characteristic . . . . . Gentiana
Fibrous, taste sweetish . . . . Glycyrrhiza (Spanish)

III. *True Rhizomes.*

1. Monocotyledons.

A. Periderm removed . . . . Zingiber

B. Periderm present.

a. Rhizome and roots.

α Horizontal in growth.
Light brown, few roots . . . . Convallaria
Dark brown with densely matted roots, Cypripedium
Grass-like, hollow . . . . Triticum

β Rhizome upright . . . . Veratrum Viride

b. Rhizome without roots . . . . Calamus

2. Dicotyledons.
   a. Rhizome with roots.
      α Rhizome horizontal.
         Numerous upright or curved branches and few roots . . . . Cimicifuga
         Internally deep yellow . . . . Hydrastis
         Light brown and with numerous coarse roots . . . . Leptandra
      β Rhizome oblique.
         Odor terebinthinate . . . . Serpentaria
         Odor aromatic . . . . Spigelia
      γ Rhizome upright . . . . Valeriana
   b. Rhizome without roots.
      Tuberculate . . . . Geranium
      Prominent seal-like stem-scars . . . . . Podophyllum
      Internally with reddish resin cells . . . Sanguinaria

IV. *Corm.*

Transverse reniform disks . . . . Colchici Cormis

V. *Bulbs.*

Narrow light-yellow pieces . . . . Scilla

SARSAPARILLA.

The dried root of various species of *Smilax* (Fam. Smilaceæ), perennial climbers, indigenous from Mexico to Brazil. There are four principal commercial varieties: (1) Honduras Sarsaparilla yielded by an undetermined species growing in Guatemala, Honduras and Nicaragua, and exported from Honduras and Belize; (2) Para Sarsaparilla, yielded by *Smilax papyracea* growing in the upper Amazon region, and exported from Para; (3) Mexican Sarsaparilla, yielded probably by *Smilax medica* growing in Mexico, and exported from Vera Cruz and Tampico, and (4) Jamaica Sarsaparilla, obtained from uncertain species of *Smilax*, growing in the United States of Colombia, Costa Rica and Nicaragua, and shipped to Jamaica, from whence it is exported—chiefly to London. There is also a native Jamaica Sarsaparilla

which is obtained from plants cultivated in Jamaica. The Honduras and Mexican varieties are chiefly used in this country, although Para Sarsaparilla has been employed to a certain extent for years.

Description.—**Honduras Sarsaparilla.**—In bundles about 1 m. in length and from 8 to 15 cm. in diameter, consisting of the long-folded roots and rhizomes, bound together by roots of the same plant or stems of some other plant, the ends of the bundles trimmed in some cases by cutting; roots about 2 m. long and uniformly about 2 to 6 mm. in diameter; externally dark or reddish brown, longitudinally furrowed, minutely hairy and having slender rootlets, the furrows usually free from soil; fracture fibrous; internally consisting of a white pith, a light-yellow porous central cylinder and a grayish white or dark-brown cortex, the latter being lighter and more starchy near the growing end, and darker (more resinous) near the union with the rhizome; odor slight; taste slightly acrid.

The cells of the endodermis and hypodermis are oblong in transverse section and nearly uniformly thickened.

Mexican Sarsaparilla. — In bundles, with the roots more or less free; the latter grayish brown, somewhat shrunken, the furrows containing larger or smaller amounts of soil. The outer walls of the cells of the hypodermis and the inner walls of the cells of the endodermis are considerably thickened.

Para Sarsaparilla.—Closely resembling the Honduras Sarsaparilla.

Constituents.—Sarsaparilla contains three glucosidal principles—parillin, saponin and sarsosaponin, of which the latter is the most active; it also contains calcium oxalate, volatile oil, resin, and, except in the Jamaica variety, starch in considerable amount.

Allied Products.—American sarsaparilla is the rhizome of *Aralia nudicaulis* (Fam. Araliaceæ), a perennial acaulescent herb, indigenous to Canada and Northern United States as far west as Nebraska. The rhizome is of variable length, from 5 to 15 mm. thick; externally brownish gray and somewhat annulate; internally light brown, more or less spongy, and having an aromatic odor and taste. It contains about 0·33 per cent. of a volatile oil, which is bitter and pungent; 3 per cent. of resin; tannin, starch and calcium oxalate.

ALTHÆA (Marshmallow).

The dried root of *Althæa officinalis* (Fam. Malvaceæ), a perennial herb, native of Central and Southern Europe, and naturalized in the United States in the salt marshes from Massachusetts to Pennsylvania. The commercial supply is obtained from cultivated plants in Germany, France and Holland. The roots are collected from plants of the second year's growth, and the periderm and rootlets removed.

Description.—Nearly entire, cylindrical, tapering, 10 to 20 cm. long, 5 to 20 mm. in diameter; externally very light brown, obscurely 4 to 6-angled, deeply furrowed longitudinally, covered with detachable bast fibers, with few circular root-scars; fracture of bark tough, fibrous, of wood short and granular; internally light brown, finely radiate, bark 0·5 to 2 mm. thick, and easily separable from the wood, cambium zone marked by a distinct brown line, wood porous; odor faint, aromatic; taste sweetish, mucilaginous.

Constituents.—Mucilage 25 to 35 per cent.; asparagin 1 to 2 per cent.; starch about 35 per cent.; pectin about 10 per cent.; sugar about 10 per cent.; ash about 5 per cent.

JALAPA (Jalap).

The tuberous root or tubercle of *Exogonium Purga* (Fam. Convolvulaceæ), a perennial twining herb, native of the eastern slopes of the Mexican Andes, and cultivated in Jamaica and India. The roots are collected in the fall and dried by artificial means, the larger ones being first cut into longitudinal pieces. Mexico furnishes the principal part of the commercial supply, which is exported from Vera Cruz.

Description.—Fusiform, irregularly ovoid or pyriform, upper end more or less rounded, lower end obtuse or slightly acuminate; 3 to 8 cm. long, 1 to 5 cm. in diameter; externally dark brown, deeply and irregularly furrowed longitudinally, otherwise nearly smooth or wrinkled, with numerous lenticels 2 to 4 mm. long and few circular rootlet scars; fracture horny and resinous; internally dark brown and marked by more or less distinct, secondary, concentric cambium zones; odor fruity; taste starchy and slightly acrid.

Tubercles which have a specific gravity less than 1·275 and are white internally should be rejected.

Constituents.—Resin 7 to 20 per cent., 90 per cent. of which consists of a glucoside, jalapurgin (convolvulin), which is insoluble in ether and is the more active constituent, and jalapin which is soluble in ether and resembles scammonin; jalap also contains calcium oxalate, starch, gum and sugar.

Allied Plants.—*Ipomæa simulans*, indigenous to the eastern slope of the Mexican Andes, yields the Tampico jalap, which is more or less uniform in thickness, somewhat tortuous, and without any lenticels; it contains about 10 per cent. of resin, which is completely soluble in ether and resembles scammonin.

KRAMERIA (Rhatany).

The root of various species of *Krameria* (Fam. Leguminosæ), shrubs indigenous to South America, Mexico and the West Indies. There are three principal commercial varieties: (1) Peruvian Rhatany, which is yielded by *Krameria triandra* and obtained from plants growing in Peru and Bolivia; (2) Savanilla Rhatany, which is derived from more or less disputed species of *Krameria* growing in the United States of Colombia, British Guiana and Brazil, and (3) Para Rhatany which is supposed to be derived from *Krameria argentea* growing in Brazil.

Description.—**Peruvian Rhatany.**—Consisting of a more or less cylindrical crown 50 mm. long and 15 to 20 mm. in diameter, and numerous cylindrical, somewhat tapering, branching roots 10 to 40 cm. long and 1 to 7 mm. thick; externally brownish red; crown with rugged and scaly bark; roots smooth or slightly wrinkled longitudinally; fracture of bark slightly fibrous, of wood, tough and splintery; internally reddish, bark 1 to 2 mm. thick, somewhat easily separable from the lighter colored, slightly radiate wood; odor slight; wood nearly tasteless, bark astringent.

Savanilla Rhatany.—Crown more or less cylindrical or spherical, rough, knotty; externally dark reddish brown, with numerous transverse fissures at more or less regular intervals; periderm not scaly; bark about twice as thick as that of Peruvian rhatany.

Para Rhatany closely resembles the Savanilla variety.

Constituents.—Tannin from 8 to 20 per cent., starch and calcium oxalate.

The tincture of Savanilla rhatany forms a clear solution with water, which gives with alcoholic lead acetate test-solution a purplish precipitate and a colorless filtrate; the tincture of Peruvian rhatany forms a

cloudy mixture with water, and gives with alcoholic lead acetate test-solution a reddish-brown precipitate and a light-brown filtrate.

PYRETHRUM (Pellitory).

The root of *Anacyclus Pyrethrum* (Fam. Compositæ), a perennial herb indigenous to Northern Africa and Southern Europe, the commercial article coming from Algeria. The root is collected in autumn and dried.

Description.—Nearly cylindrical, slightly tapering or broken into irregular pieces, 2·5 to 10 cm. long, 3 to 20 mm. in diameter; externally dark brown, wrinkled and somewhat furrowed longitudinally, with few rootlets or rootlet scars; crown somewhat annulate from scars of bud-scales, and sometimes tufted with coarse fibers of fibrovascular tissue or with long, soft-woolly, nearly straight one-celled hairs; fracture short and horny when dry, tough when damp; internally, bark dark brown, with two circular rows of secretion reservoirs, 0·5 to 1 mm. thick, and closely adhering to the light-yellow radiate porous wood, in the medullary rays of which secretion reservoirs are also found; odor distinct, penetrating; taste pungent, acrid.

Constituents.—An alkaloid pyrethrine, which occurs in colorless, acicular crystals and has an intense pungent taste; fixed oil, volatile oil, resin, and 50 per cent. of inulin.

Allied Plants.—German pellitory, the root of *Anacyclus officinarum*, is smaller; the bark contains but one row of secretion reservoirs, which are wanting in the medullary rays; the roots also contain tannin.

SENEGA (Senega Root).

The dried root of *Polygala Senega* (Fam. Polygalaceæ), a perennial herb indigenous to the Southern United States. There are two representative commercial varie-

ties—the northern, collected in Manitoba and in the State of Minnesota; the southern, from Virginia to Texas.

Description.—Nearly entire, with broken and detached rootlets, crowned with numerous buds and short-stem remnants, slenderly conical, more or less tortuous, somewhat branched, 3 to 8 cm. long, 2 to 12 mm. thick; externally dark yellow, the crown being rose-tinted, longitudinally wrinkled, slightly annulate, marked with circular scars of detached rootlets and in some cases by a keel which is more prominent near the crown in perfectly dry roots; side opposite keel more or less flattened; cross-section elliptical or triangular; fracture short when dry, tough when damp; internally, wood lemon-yellow, 2 to 5 mm. in diameter, usually excentral, bark dark yellow, much thickened on one side, forming on drying, the keel; odor slight, penetrating; taste sweetish and acrid.

Constituents.—The principal constituents are two glucosides: senegin, which resembles saponin, 2 to 5 per cent., and polygalic acid, which is sternuatory. The root also contains 0·12 per cent. of a volatile oil which is chiefly methyl salicylate; resin, pectin, sugar and considerable proteids.

TARAXACUM (Dandelion).

The root of *Taraxacum officinale* (Fam. Compositæ), a perennial herb indigenous to Europe and Asia, but now naturalized in all civilized parts of the world. The root should be collected in spring or in autumn either directly before or directly after the vegetative activity of the plant. It is used in either the fresh or dried condition, the principal supply of the dried root coming from Europe. The drug should be preserved from the attacks of insects by a few drops of chloroform.

Description. — Somewhat cylindrical, tapering, more or less flattened, slightly branched or broken into irregular pieces 6 to 15 cm. long, 5 to 15 mm. in diameter; externally light brown, wrinkled, with numerous rootlet scars; crown simple or branched, slightly annulate from numerous leaf-bases; fracture short, horny when dry, tough when damp; internally, bark light brown, 2 to 6 mm. thick, made up of concentric layers of laticiferous vessels and sieve alternating with white parenchyma, wood lemon-yellow, 1 to 4 mm. thick, porous and non-radiate; odor slight; taste bitter.

Constituents.—The drug contains two bitter principles—one which is amorphous, and another which is crystalline and called taraxacin; another principle has been isolated which gives reactions with certain of the alkaloidal reagents; it also contains pectin, 24 per cent. of inulin, and about 5 per cent. of ash.

CALUMBA (Columbo).

The root of *Jateorhiza palmata* (Fam. Menispermaceæ), a perennial herbaceous climber, native of the forests of Eastern Africa. The large fleshy roots are collected in the dry season, cut into transverse pieces, dried and exported by way of Zanzibar and Bombay.

Description.—In nearly circular or elliptical disks, sometimes irregularly bent, 2 to 5 cm. in diameter, 2 to 10 mm. thick; externally yellowish green or dark brown, wrinkled; fracture short, mealy; internally radiate yellowish green, wood bundles concentric, bark 4 to 6 mm. thick, cambium zone distinct, center either depressed or more or less prominent; odor slight; taste bitter and aromatic.

Constituents.—Columbin about 0·83 per cent., ber-

berine, columbic acid, starch about 35 per cent., calcium oxalate, mucilage, and 6 per cent. of ash.

SUBSTITUTES.—Various substitutes for calumba have been offered, but these are free from starch, or they may contain tannin, as American columbo, the root of *Frasera Carolinensis*, an herb indigenous to the Eastern United States.

PAREIRA (Pareira Brava).

The root of *Chondrodendron tomentosum* (Fam. Menispermaceæ), a perennial climber indigenous to Brazil and Peru. The commercial article is exported from Rio Janeiro.

DESCRIPTION.—Nearly cylindrical, more or less tortuous, cut into pieces of various lengths, usually from 10 to 20 cm. long and 10 to 30 mm. in diameter, rootlets few; externally brownish black, longitudinally furrowed and transversely ridged and fissured, with numerous rootlet scars and occasional grayish patches of lichens; fracture fibrous, lustrous when cut; internally dark brown, with three or more irregularly excentral, distinctly radiate zones of secondary fibrovascular bundles, each 2 to 3 mm. wide, and separated by distinct zones of parenchyma and stone cells; odor slight; taste slightly bitter.

CONSTITUENTS.—An alkaloid pelosine (cissampeline) somewhat resembling beberine in bebeeru bark (*Nectandra Rodiaei*) and buxine in box bark (*Buxus sempervirens*); starch, tannin, wax, ash 4 to 5 per cent.

SUBSTITUTES.—Other roots are frequently substituted for genuine pareira brava, which are no doubt derived from other menispermaceous plants; these roots are of a brownish color, possess numerous concentric zones of fibrovascular bundles, and do not have a waxy luster when cut. The stems of *Chondrodendron tomen-*

tosum are also sometimes found in the drug; these are more woody, possess a distinct pith and are marked externally by the apothecia of lichens.

STILLINGIA (Queen's Root).

The root of *Stillingia sylvatica* (Fam. Euphorbiaceæ), a perennial herb indigenous to the Southern United States. The root is collected in August; it is deprived of its rootlets, cut into transverse pieces and carefully dried.

Description. — Cylindrical, tapering, and slightly branched; usually cut into pieces 2 to 10 cm. long, 5 to 30 mm. in diameter; externally dark brown, longitudinally wrinkled, rootlets or rootlet scars few; fracture of bark fibrous; internally, bark light reddish brown, 0·5 to 4 mm. thick, soft, spongy, with numerous resin cells and easily separable from the porous radiate wood; odor faint; taste bitter, acrid and pungent.

Constituents.—A volatile oil with the odor and taste of the root; an acrid resin sylvacrol; starch; calcium oxalate; ash about 5 per cent.; tannin and probably a glucoside.

SUMBUL.

The rhizome and root of *Ferula Sumbul* (Fam. Umbelliferæ), a perennial herb indigenous to Turkestan. The drug is exported by way of St. Petersburg.

Description.—In cylindrical, sometimes branched, transverse segments, 3 to 10 cm. long and 1·5 to 7 cm. in diameter, very light; externally light to dark brown, distinctly annulate, periderm easily separable; the upper part of the rhizome with occasional circular scars and leaf-remnants consisting of stout fibers of fibrovascular tissue; fracture short, fibrous but irregular; internally light yellow, resinous, spongy,

porous, arrangement of wood irregular, due to anomalous secondary cambiums, bark dark brown, about 0·5 mm. thick; odor musk-like; taste bitter, pungent.

CONSTITUENTS.—Volatile oil having the taste of peppermint, from 0·3 to 1 per cent.; two balsamic resins, one soluble in alcohol and having the odor and taste of the root, the other soluble in ether; fixed oil 17 per cent.; ash about 8 per cent.; starch, and several acids, as angelic, valerianic and methyl-crotonic.

BELLADONNÆ RADIX (Belladonna Root).

The root of *Atropa Belladonna* (Fam. Solanaceæ), a perennial herb native of Central and Southern Europe, and cultivated in England and Germany, from which countries most of the commercial supply is obtained. The roots are collected in autumn from plants three to four years old and carefully dried.

DESCRIPTION.—Cylindrical, slightly tapering, somewhat twisted, or split into longitudinal pieces 5 to 15 cm. long, 4 to 25 mm. in diameter; externally light brown, smooth, longitudinally wrinkled or fissured, sometimes with transverse ridges and with rootlet scars or fragments of rootlets; fracture short, mealy when dry, tough when damp; internally light yellow, slightly radiate, bark 0·5 to 2 mm. thick, not fibrous, and adhering closely to the wood, cambium zone distinct; odor narcotic; taste sweetish, acrid.

Roots that are shrunken, spongy, dark brown and free from starch should be rejected, as also old woody roots and stem-remnants.

Phytolacca root and Althæa are distinguished from belladonna root by having numerous sclerenchymatous fibers, and inula by having neither starch nor crypto-crystalline crystals of calcium oxalate.

CONSTITUENTS.—There are two principal alkaloids—

hyoscyamine and atropine, which together amount to 0·2 to 0·6 per cent., the proportions of these varying according to the age of the root, the hyoscyamine, however, usually being in excess. The atropine appears to be derived from its isomer hyoscyamine and not to pre-exist in the root; a small amount of scopolamine (hyoscine) is also present. Other alkaloids, as belladonnine, apoatropine, etc., have been isolated, but they appear to be decomposition products of hyoscyamine.

Allied Products.—The rhizome of *Scopola Carniolica* (Fam. Solanaceæ), a perennial herb indigenous to Austro-Hungary and the surrounding countries, is sometimes admixed with, and substituted for, belladonna root. As it occurs in commerce, the rhizome is usually split into longitudinal pieces, the entire rhizome being oblique, nearly cylindrical, somewhat tortuous, 5 to 12 cm. long, 5 to 15 mm. in diameter; externally light brown, longitudinally wrinkled, slightly annulate, upper surface with numerous circular overground stem-scars, 3 to 7 mm. in diameter, under portion with numerous root-scars and root-remnants; fracture short; internally very light brown, cell contents like those of belladonna root; closely resembling belladonna root also in odor and taste.

LAPPA (Burdock).

The root of *Arctium Lappa* and of other species of *Arctium* (Fam. Compositæ), biennial herbs indigenous to Europe and Northern Asia, and naturalized in waste places in the United States and Canada. The root is collected in autumn from plants of the first year's growth, and carefully dried.

Description.—Nearly cylindrical, slightly tapering, or broken and split longitudinally into pieces, 10 to 20 cm. long, 5 to 20 mm. in diameter; externally, bark

dark brown, longitudinally wrinkled, with few rootlets or rootlet scars, crown somewhat annulate from scars of bud-scales and sometimes surmounted by a soft woolly tuft of leaf-remains with 1-celled twisted hairs; fracture short, horny when dry, tough when damp; internally light brown, radiate, bark 2 to 3 mm. thick, wood porous, cambium zone distinct; odor feeble; taste mucilaginous, slightly bitter.

Old woody roots in which the pith is more or less obliterated and which have been collected from the fruiting plant should be rejected.

Constituents.—Inulin about 45 per cent., fixed oil, resin and a glucoside, probably identical with that found in the seed, and to which the name lappin has been applied.

PHYTOLACCÆ RADIX (Poke Root).

The root of *Phytolacca decandra* (Fam. Phytolaccaceæ), a perennial herb indigenous to Eastern North America, and naturalized in the West Indies and Southern Europe. The root is collected in autumn and, after removal of the rootlets, cut into transverse and longitudinal pieces and dried.

Description.—Fusiform or nearly cylindrical, tapering, usually in longitudinal ribbon-like slices, 8 to 16 cm. long, 5 to 15 mm. in diameter, 2 to 10 mm. thick; externally, bark dark brown, more or less wrinkled; fracture fibrous, tough; internally light brown, characterized by alternating layers of fibrovascular tissue and parenchyma formed by secondary cambiums; odor slight; taste acrid.

Constituents.—Resin 1 per cent., sugar 10 per cent., asparagin, starch about 10 per cent., calcium oxalate, ash 8 to 10 per cent. The drug contains no alkaloids, or tannin, but apparently a glucoside allied to saponin.

APOCYNUM (Canadian Hemp).

The dried root of *Apocynum cannabinum* (Fam. Apocynaceæ), a perennial herb growing in fields and thickets in the United States and Southern Canada.

DESCRIPTION. — Cylindrical, somewhat branched, usually broken into pieces 4 to 10 cm. long, 5 to 10 mm. in diameter; externally light brown, longitudinally wrinkled and transversely fissured, with few rootlets or rootlet scars; fracture short; internally, bark light brown, 1 mm. thick, easily separable from the lemon-yellow, porous, slightly radiate wood; odor slight; taste of bark bitter and acrid, of wood slightly bitter.

Stem fragments are distinguished by having a comparatively thin, finely fibrous bark and a hollow center.

CONSTITUENTS.—Apocynin an amorphous, resinous substance; apocynein a glucoside with the physiological properties of digitalin; resin, tannin, starch and about 10 per cent. of ash.

ALLIED PLANTS.—The commercial article frequently contains the root of a closely related plant *Apocynum androsæmifolium*, which has a thinner bark and contains one or more groups of stone cells.

IPECACUANHA (Ipecac).

The dried root of *Cephaëlis Ipecacuanha* (Brotero) A. Richard (Syn. *Uragoga Ipecacuanha* Baillon) (Fam. Rubiaceæ), a shrub indigenous to Brazil, and sparingly cultivated near Singapore. The commercial supply is obtained from Matta Grosso, Brazil, and is known as Brazilian or Rio Ipecac. The roots of a plant closely related to *Cephaëlis Ipecacuanha* and indigenous to the northern and central portion of the

United States of Colombia, are exported from Carthagena and Savanilla, and are known commercially as Carthagena Ipecac.

Description.—**Rio or Brazilian Ipecac.**—Cylindrical, more or less tortuous, 5 to 15 cm. long, 1 to 5 mm. in diameter; externally dark brown, irregularly annulate, sometimes transversely fissured, with occasional rootlets or rootlet scars; fracture of bark brittle, of the wood tough; internally, bark light brown, 0·5 to 1 mm. thick, easily separable from the dark-yellow non-porous wood; odor slight; taste bitter, acrid.

Carthagena Ipecac closely resembles the Rio or Brazilian ipecac, but the roots are uniformly thicker (4 to 7 mm. in diameter) and the annulations are less pronounced.

Stems usually more slender, 5 to 10 cm. long, 1 to 1·5 mm. in diameter, nearly smooth or longitudinally wrinkled, bark 0·1 mm. thick, with bast fibers either single or in groups, pith distinct, 0·5 mm. in diameter.

Constituents.—Ipecac contains three alkaloids (2 to 3 per cent.)—emetine, cephaëline and psychotrine; a glucoside resembling saponin; starch, in considerable quantity, and calcium oxalate.

The total amount of alkaloids in Rio and Carthagena ipecac not only varies but there is a difference in the proportions of emetine and cephaëline: in Rio ipecac the proportion is one-third cephaëline to two-thirds emetine, while in Carthagena ipecac there are four-fifths cephaëline to one-fifth emetine.

Plants with Similar Properties.—A number of plants have been proposed to replace ipecac, the most important of which is *Sycocarpus Rusbyi* (Fam. Meliaceæ), a tree indigenous to Bolivia and yielding Cocillana bark, which contains several alkaloids but no emetine. Five or six other drugs, some of which

resemble ipecac, sometimes find their way into commerce, and while they all possess emetic properties, none of them contain emetine.

GLYCYRRHIZA (Licorice Root).

The dried rhizome and root of *Glycyrrhiza glabra*, and of the var. *glandulifera* (Fam. Leguminosæ), perennial herbs indigenous from Southern Europe to Central Asia, and extensively cultivated in Spain, Southern France and Italy. There are two principal commercial varieties: (1) Spanish Licorice, yielded by cultivated plants of *G. glabra*, and chiefly exported from Spain and Southern France, and (2) Russian Licorice, obtained from wild plants of *G. glabra*, var. *glandulifera*, growing in Southern Russia. The latter consists more largely of roots which are deprived of the periderm, whereas the Spanish variety consists mostly of rhizomes.

Description.—**Spanish Licorice.**—Nearly cylindrical, more or less tortuous, cut or broken into pieces 14 to 20 cm. long, 5 to 25 mm. in diameter; crown knotty; externally dark brown, longitudinally wrinkled or furrowed, with few rootlet scars, rhizome with corky patches and numerous small conical buds; fracture coarsely fibrous; internally lemon-yellow, radiate, bark 1 to 3 mm. thick, wood porous, rhizome with small pith; odor distinct; taste sweetish, slightly acrid.

Russian Licorice.—Nearly cylindrical, tapering, sometimes split longitudinally, 15 to 30 cm. long, 10 to 30 mm. in diameter; externally lemon-yellow, nearly smooth, porous, with detachable bast fibers and circular rootlet scars, cork, if present, more or less easily detachable; internally lemon-yellow, bark coarsely fibrous, wood radially cleft, not so fibrous as the Spanish variety.

Constituents.—A glucoside glycyrrhizin from 2·5 to 6 per cent. (Russian licorice is said to contain as much as 7·5 per cent.), asparagin 3 per cent., glycyramarin, mannit, starch, calcium oxalate and resin.

Allied and Other Plants.—The root of wild licorice, *Glycyrrhiza lepidota*, a perennial herb indigenous to Western North America, is somewhat similar to Spanish licorice, but is more bitter and less sweet. Glycyrrhizin has also been obtained from the roots of *Abrus precatorius* and *Ononis spinosa*, the rhizome of *Polypodium vulgare* and various parts of a number of other plants.

RHEUM (Rhubarb).

The rhizome of *Rheum officinale*, *Rheum palmatum*, *Rheum palmatum*, var. *tanguticum*, and probably other species of *Rheum* (Fam. Polygonaceæ), perennial herbs indigenous to Northwestern China and Eastern Thibet, and sparingly cultivated in other parts of the world. The rhizomes are collected in autumn from plants that are eight to ten years old, most of the bark is removed, and they are then perforated, strung on ropes and dried either in the sun or by artificial heat. The drug is exported chiefly from Shanghai. The principal commercial varieties are known as Chinese rhubarb, Canton rhubarb and Shensi rhubarb, the latter being preferred.

Description.—Cut into irregular plano-convex and oblong pieces, frequently with a large perforation, hard and moderately heavy, 5 to 15 cm. long, 5 to 8 cm. broad and 3 to 6 cm. thick; externally mottled from alternating striæ of light-brown parenchyma cells and dark-brown medullary rays, occasionally with reddish-brown cork patches and small radiate scars of fibro-vascular tissue, smooth and sometimes covered with a

light-brown powder; fracture somewhat granular; internally light brown; odor distinct; taste bitter, astringent and gritty.

Light and spongy rhizomes should be rejected.

Constituents.—The principal constituent appears to be a glucoside which yields chrysophanic acid, emodin and rhein; the drug also contains tannin, several resins, considerable starch, calcium oxalate, and yields about 15 per cent. of ash.

Allied Plants.—The rhizomes of other species of *Rheum* are also used to a limited extent, as English or Austrian rhubarb from *Rheum rhaponticum;* they are more or less cylindrical, distinctly radiate, and contain, besides chrysophanic acid, rhapontin. *Rheum palmatum,* which is cultivated in France, Germany and Russia, produces rhizomes that are lighter in color and less valuable than the Chinese rhubarb, the constituents being similar to those of Austrian rhubarb.

ACONITUM (Aconite).

The tuberous root of *Aconitum Napellus* (Fam. Ranunculaceæ), a perennial herb growing in the mountainous districts of Europe, Asia and Western North America. It is also cultivated in temperate regions. The commercial supplies are obtained from England and Germany, and in England the root is collected in autumn from cultivated plants after the overground parts have died down, whereas in Germany the roots are collected from wild plants during the flowering period, this being done to distinguish the particular species yielding the drug. The root should be carefully dried.

Description.—More or less conical or fusiform, 4 to 10 cm. long, 5 to 20 mm. in diameter; externally dark brown, smooth or somewhat wrinkled, the upper portion with a bud, remains of bud-scales or stem-scars,

with numerous root-scars or short roots; fracture horny, somewhat mealy; internally, bark light or dark brown, 1 to 2 mm. thick, cambium irregular, 5 to 7-angled, wood yellowish, in small bundles at the angles, pith light brown, about 2 to 6 mm. in diameter; odor very slight; taste sweetish, acrid, pungent, accompanied by a sensation of numbness and tingling.

The shrunken, hollow, older tubers, together with the overground stem-remnants, should be rejected.

CONSTITUENTS.—A number of alkaloids have been isolated, of which aconitine is the most important; it occurs in rhombic prisms, and gives the characteristic properties to the root. The other alkaloids are amorphous and non-toxic, and of these isaconitine (napelline) has been employed medicinally.

ALLIED PLANTS.—Japanese aconite is obtained from *Aconitum Fischeri;* the root is smaller but appears to contain similar constituents. Indian aconite, the product of *Aconitum ferox*, is a much larger root and somewhat horny, owing to the gelatinization of the starch in its preparation for market, and apparently contains more napelline and less aconitine than the official drug.

GELSEMIUM (Yellow Jessamine, Yellow Jasmine).

The rhizome and roots of *Gelsemium sempervirens* (Fam. Loganiaceæ), a perennial climber of the Southern United States and Guatemala. The drug should be collected in autumn.

DESCRIPTION.—Rhizome horizontal, cylindrical, usually cut into pieces 9 to 20 cm. long, 4 to 15 mm. in diameter; externally light brown, longitudinally wrinkled, transversely fissured; upper surface with few stem-scars; under and side portions with numerous roots and root-scars; fracture tough, wiry; internally light brown or pale yellow, bark about 1 mm. thick,

wood distinctly radiate, excentral, with four groups of internal phloem, pith disintegrated; odor slight; taste bitter.

Roots light brown, 3 to 20 cm. long, 2 to 8 mm. thick; internally light yellow, bark about 0·5 mm. thick, wood distinctly radiate.

The overground stem is dark or reddish-brown, longitudinally wrinkled and has numerous lenticels and few somewhat elliptical branch-scars; the bark is about 0·2 mm. thick and somewhat greenish.

Constituents.—Two alkaloids of great toxicity, the one bitter, amorphous, yielding crystalline salts and known as gelsemine, the other crystalline, forming amorphous salts and known as gelseminine. In addition the drug contains gelsemic acid; a bluish green, fluorescent principle known as β-methyl-æsculetin; volatile oil, resin, starch and calcium oxalate.

GENTIANA (Gentian).

The rhizome and roots of *Gentiana lutea* (Fam. Gentianaceæ), a perennial herb indigenous to Central Europe. The fleshy rhizomes and roots are collected in autumn and frequently cut into longitudinal pieces and slowly dried, during which latter process they develop a distinctive color and odor. The commercial supplies are obtained from France, Germany, Spain and Switzerland.

Description. — Nearly cylindrical and sometimes branched, split longitudinally or broken into irregular pieces, 3 to 15 cm. long, 5 to 40 mm. in diameter; externally light brown, the upper or rhizome portion annulate from scars of bud-scales, longitudinally wrinkled, and with few buds, stem and root-scars, roots longitudinally wrinkled; fracture short when dry, tough and flexible when damp; internally dark yellow,

bark 0·5 to 2 mm. thick, porous, cambium zone distinct; odor heavy; taste bitter.

Constituents. — A bitter glucoside, gentiopicrin, about 0·1 per cent.; a crystalline, bitter glucoside; a coloring principle gentisin (gentianin or gentisic acid) becoming greenish brown with ferric salts; quercitrin, gentianose (a carbohydrate which occurs in the fresh root) and pectin.

Allied Plants.—The rhizome and roots of various other European species of *Gentiana* are sometimes collected and employed medicinally, as of *Gentiana purpurea,* collected in Switzerland, and *G. Pannonica* and *G. Punctata,* collected in Austria. The rhizome and roots of Elliott's gentian, *Gentiana Elliottii,* indigenous to the southeastern part of the United States, was at one time official in this country.

ZINGIBER (Ginger).

The rhizome of *Zingiber officinale* (Fam. Zingiberaceæ), a perennial herb indigenous to Asia, and cultivated in most tropical countries, notably in the West Indies and Africa. The rhizomes are collected between December and March; they are cleaned by washing, peeled, again washed in water, sometimes containing lime-juice, and dried in the sun. There are several kinds of the drug, depending upon the manner of treatment — that from Africa has the periderm removed from the vertical sides only, and is known as "coated" or "uncoated" ginger; in the Jamaica variety the periderm is completely removed and the product is known as "peeled" or "scraped" ginger. The latter is sometimes steeped in milk of lime to protect it against the attacks of insects. Cochin, Japanese and East Indian gingers closely resemble the African, and while they contain more oil and resin than the

Jamaica, they are less aromatic and are not recognized by the pharmacopœias.

Description.—Horizontal, latterly compressed, irregularly branched pieces, 4 to 10 cm. long, 4 to 20 mm. broad, 5 to 10 mm. thick ; externally light brown, longitudinally wrinkled, with somewhat elliptical depressed stem-scars, with few fibers of fibrovascular tissue or adhering fragments of periderm; fracture mealy and with short projecting fibrovascular bundles; internally, cortex light brown, 0·1 to 0·4 mm. thick ; central cylinder with numerous circular groups of fibrovascular tissue and yellowish secretion cells; odor strongly aromatic; taste pungent.

Constituents.—Volatile oil, possessing the aromatic odor of the drug, about 2 per cent.; a viscid principle gingerol, which has the pungent taste of the drug; resin; starch 20 per cent.

CONVALLARIA (Lily-of-the-Valley).

The dried rhizome and roots of *Convallaria majalis* (Fam. Liliaceæ), a perennial herb indigenous to Europe, Asia and the higher mountains of Virginia, North Carolina and South Carolina. The rhizome and roots should be collected late in summer and carefully dried. The leaves and flowers have also been used in medicine.

Description.—Rhizome horizontal, cylindrical, and sometimes branched, jointed in pieces from 3 to 17 cm. long, internodes 10 to 50 mm. long, 1 to 3 mm. in diameter, nodes with a circular scar, not much thickened; externally light or dark brown, longitudinally wrinkled, somewhat annulate from scars of bud-scales, mostly smooth between the nodes, upper surface of nodes marked by stem-scars, side and under surface with root-scars, or usually with three to five roots, fracture

short or fibrous; internally light or dark brown, cortex 0·5 mm. thick, separable from the central cylinder; odor faint; taste bitter, slightly acrid.

Roots somewhat tortuous, 5 to 6 cm. long, about 0·3 to 0·5 mm. in diameter, rootlets few.

CONSTITUENTS.—Two glucosides, one bitter, having a physiological action similar to digitalin, and known as convallamarin; the other acrid, somewhat resembling saponin, and known as convallarin; a resin is also present.

CYPRIPEDIUM (Lady's Slipper).

The dried rhizome and roots of *Cypripedium pubescens* Willdenow (Syn. *C. hirsutum* Miller), and *Cypripedium parviflorum* (Fam. Orchidaceæ), perennial herbs native in woods and thickets of the Eastern and Central United States and Canada.

DESCRIPTION.—Rhizome horizontal, somewhat tortuous and bent, 3 to 7 cm. long, 2 to 4 mm. in diameter; externally dark brown, annulate from scars of bud-scales, upper surface with numerous large, sometimes depressed scars, under and side portions with numerous roots and few root-scars; fracture short; internally light brown, cortex about 0·5 mm. thick, central cylinder somewhat porous, and with numerous circular groups of fibrovascular bundles; odor heavy, distinct; taste bitter, somewhat pungent.

Roots 3 to 11 cm. long, 0·5 to 1·5 mm. in diameter; externally light or dark brown, longitudinally wrinkled; fracture somewhat fibrous; internally, cortex white, central cylinder yellowish.

CONSTITUENTS.—Volatile oil, several resins, a bitter glucosidal principle, tannin, starch, calcium oxalate, and ash about 6 per cent.

TRITICUM (Couch Grass).

The rhizome of *Agropyron repens* (Fam. Gramineæ), a perennial grass indigenous to Europe and Asia, and naturalized in North America, except in the Arctic region. The rhizome is gathered in spring, deprived of the rootlets, cut into pieces and carefully dried.

Description.—Horizontal, somewhat cylindrical or 4 to 6-angled, usually cut into pieces 5 to 8 mm. long, 1 to 2 mm. in diameter; externally light yellow, longitudinally furrowed, smooth, shiny, nodes with circular leaf-scars and few root-scars; fracture tough, fibrous; internally, bark light brown, about 0·5 mm. thick, wood light yellow and porous, center hollow; odor slight, taste sweetish, slightly acrid.

Constituents.—Triticin, a carbohydrate resembling inulin, 8 per cent.; sugar about 3 per cent. The rhizome is free from starch and calcium oxalate, and the lactic acid found in the extract is apparently a fermentation product.

VERATRUM VIRIDE (American White Hellebore).

The rhizome and roots of *Veratrum viride* (Fam. Liliaceæ), a perennial herb indigenous to the Eastern and Central United States and found growing from Quebec to British Columbia and Alaska. The rhizome is collected in autumn, cut longitudinally and dried. *Veratrum album*, which is indigenous to Central and Southern Europe, produces a rhizome similar to the American species, and much of the drug used in this country is derived from this species and imported from Germany.

Description.—Rhizome upright, obconical, usually cut longitudinally into halves or quarters, 2·5 to 5 cm. long, 1·5 to 3 cm. in diameter; externally dark brown, rough and wrinkled, somewhat annulate from scars of

bud-scales, top truncate, lower part more or less decayed, with numerous roots and few root-scars; fracture hard and horny; internally light yellow, cortex 2 to 3 mm. thick, endodermis distinct, central cylinder with yellow circular groups of fibrovascular bundles; odor slight; taste bitter and acrid.

Roots yellowish brown, nearly cylindrical, 3 to 8 cm. long, 2 to 3 mm. in diameter; externally yellowish brown, longitudinally or transversely wrinkled; internally, bark white, 1 to 2 mm. thick; wood porous, cylindrical; fracture short.

The leaf and stem bases, if present, should be removed.

CONSTITUENTS.—The drug contains a number of alkaloids, of which the most important is protoveratrine (probably veratroidine); it is amorphous and sternutatory and occurs to the extent of 0·03 per cent in the roots; the others include protoveratridine, jervine, rubijervine, pseudojervine and possibly also cevadine; in addition, the drug contains a number of organic acids, fixed oil, starch, calcium oxalate, and ash 3 to 4 per cent.

The constituents of Veratrum album are similar to those of Veratrum viride.

CALAMUS (Sweet Flag).

The dried rhizome of *Acorus Calamus* (Fam. Araceæ), a perennial herb widely distributed in all northern temperate regions. The commercial supplies are obtained from the United States, Germany, England, Russia and India. The rhizomes are collected in autumn, the drug from India being the more aromatic, whereas the German product, on account of the removal of the outer portion of the rhizome, is probably the least aromatic.

Description.—Horizontal, cylindrical, slightly compressed, usually split longitudinally into pieces 5 to 15 cm. long, 5 to 12 mm. in diameter; externally light brown or yellowish green, annulate from remnants of circular bud-scales, upper surface with triangular leaf-scars or hair-like fibers of fibrovascular tissue, the sides with large circular branch-scars, and the under and side portions with root-scars or short fragments of roots; fracture short; internally light brown, distinctly porous, with numerous intercellular spaces, endodermis distinct; odor aromatic; taste strongly aromatic.

Constituents.—Volatile oil 0·1 per cent.; acorin, a bitter viscid glucosidal principle; a crystalline alkaloid calamine; resin; tannin; mucilage; starch and calcium oxalate.

An Indian variety contains from 1 to 2·5 per cent. of oil and is mostly preferred.

CIMICIFUGA (Black Snakeroot, Black Cohosh).

The dried rhizome and roots of *Cimicifuga racemosa* (Fam. Ranunculaceæ), a perennial herb indigenous to Asia, Eastern Europe and North America. The drug is collected in autumn, the United States furnishing the principal supply.

Description.—Rhizome horizontal, with numerous upright or curved branches and few roots, 2 to 15 cm. long, 1 to 2·5 cm. in diameter; externally dark brown, slightly annulate from circular scars of bud-scales, the upper surface with buds, stem-scars and stem-remnants, under and side portions with numerous root scars and few roots; fracture horny; internally, bark dark green, about 1 mm. thick, wood dark brown, 4 to 5 mm. thick, distinctly radiate; pith 3 to 5 mm. in diameter; odor slight; taste bitter and acrid.

Roots brittle, nearly cylindrical or obtusely quad-

rangular; externally dark brown, longitudinally wrinkled, 3 to 12 cm. long, 1 to 2 mm. in diameter; fracture short; internally, bark dark brown, 0·2 to 0·4 mm. thick, wood light brown, usually four-rayed.

CONSTITUENTS.—Cimicifugin, a bitter, acrid, crystalline principle; two resins amounting to about 3 per cent.; volatile oil; starch and a tannin-like principle giving a green color with ferric salts (distinguishing the drug from the rhizome of *Helleborus niger*).

HYDRASTIS (Golden Seal).

The dried rhizome and roots of *Hydrastis Canadensis* (Fam. Ranunculaceæ), a perennial herb indigenous to the Eastern United States and Canada. The rhizome and roots are collected in autumn.

DESCRIPTION.—Rhizome horizontal or oblique, subcylindrical, 2 to 5 cm. long, 3 to 6 mm. in diameter; externally yellowish or dark brown, slightly annulate from circular scars of bud-scales, upper surface with numerous short stem-remnants or stem-scars, under and side portions with numerous roots or root-scars; fracture short, waxy; internally deep yellow, bark about 0·5 mm. thick, wood radiate, about 1 mm. thick, pith light yellow; odor distinct; taste bitter.

Roots 4 to 7 cm. long, 0·2 to 0·4 mm. in diameter; internally bright yellow, wood somewhat quadrangular.

CONSTITUENTS.—Two alkaloids—one, hydrastine, occurring in colorless prisms, and to the extent of 1·5 per cent.; the other, berberine, occurring in yellow needles, and to the extent of 3 to 4 per cent. In addition, the drug contains a small amount of an alkaloid canadine, a resin, a fluorescent principle and starch.

LEPTANDRA (Culver's Root).

The rhizome and roots of *Leptandra Virginica* (Fam. Scrophulariaceæ), a perennial herb growing in meadows and moist woods of the Eastern and Central United States and Canada. The rhizome and roots are collected in autumn from plants of the second year's growth.

DESCRIPTION.—Rhizome horizontal, nearly cylindrical, somewhat branched, 4 to 10 cm. long, 3 to 8 mm. in diameter; externally light brown to brownish red; annulate from circular scars of bud-scales, upper surface with conical buds, short stem-remnants or stem-scars, the under and side portions with numerous roots or root-scars; fracture tough; internally, bark dark brown, 0·3 to 1 mm. thick, wood about 0·5 to 1·5 mm. thick, pith light brown or brownish black; odor slight; taste bitter, slightly acrid.

Roots from 1 to 4 cm. long, 0·5 to 1 mm. in diameter, externally smooth; longitudinally wrinkled, fracture short; internally, bark brownish black, wood light brown.

CONSTITUENTS.—Leptandrin, a crystalline glucoside; resin, about 6 per cent.; saponin; tannin; starch; and either a volatile oil or a volatile alkaloid.

SERPENTARIA.

The rhizome and roots of several species of *Aristolochia* (Fam. Aristolochiaceæ), perennial herbs indigenous to the Southern United States. There are two commercial varieties: (1) Virginia Snakeroot, yielded by *Aristolochia Serpentaria*, found growing east of the Mississippi, and (2) Texas or Red River Snakeroot, yielded by *Aristolochia reticulata*, and growing west of the Mississippi. The rhizome and roots are collected in autumn and dried.

Description.—**Virginia Snakeroot.**—Rhizome oblique, subcylindrical, with numerous roots and frequently with leaves or fruiting stems, 10 to 25 mm. long, and 2 to 4 mm. in diameter; externally dark brown, slightly annulate from scars of bud-scales, upper portion with stem-scars or stem-remnants, under and side portions with numerous roots and root-scars; fracture short; internally, bark dark brown, 0·3 to 0·5 mm. thick, wood yellow, radiate, porous, 1 to 1·5 mm. thick, pith 1 mm. in diameter; odor terebinthinate; taste bitter, aromatic.

Roots nearly straight, 4 to 7 cm. long, about 0·5 mm. in diameter, longitudinally wrinkled, bark light brown, wood yellowish, 5-rayed.

Texas Snakeroot.—Rhizome 5 to 10 mm. long, 1 to 2 mm. in diameter; roots about 0·3 mm. in diameter, with numerous more or less interlacing rootlets.

Constituents.—Volatile oil 0·5 to 1 per cent.; a bitter, alkaloidal principle aristolochine; resin; tannin; starch; ash about 10 per cent.

SPIGELIA (Pinkroot).

The rhizome and roots of *Spigelia Marilandica* (Fam. Loganiaceæ), a perennial herb indigenous to the Southern United States. Spigelia should be collected in autumn, carefully dried and preserved, and not kept longer than two years.

Description.—Rhizome horizontal or slightly oblique, more or less branched, 1·5 to 3 cm. long, 2 to 3 mm. in diameter; externally dark brown, slightly annulate from scars of bud-scales, the upper portion with stem-scars or stem-remnants, under and side portions with numerous roots and root-scars; fracture short; internally, bark dark brown, 0·2 to 0·5 mm. thick, wood yellow, slightly radiate, 1 to 1·5 mm. thick,

pith 1 mm. in diameter; odor slightly aromatic; taste bitter, pungent.

Roots 5 to 10 cm. long, about 0·3 mm. in diameter, with numerous rootlets; externally dark brown, longitudinally wrinkled; internally light brown, wood nearly cylindrical, porous.

CONSTITUENTS.—A volatile alkaloid spigeline, a bitter principle, volatile oil, resin, tannin and starch.

ADULTERANTS.—Spigelia is frequently found admixed with the rhizomes of other plants, among which may be mentioned that of *Phlox Carolina*, which is light brown externally and the roots of which are coarser than those of Spigelia. Another rhizome is sometimes found admixed with Spigelia, the origin of which has not been determined, and which contains calcium carbonate in special cells in the cortex.

VALERIAN (Valerian).

The rhizome and roots of *Valeriana officinalis* (Fam. Valerianaceæ), a perennial herb indigenous to Europe and Asia, and cultivated in Holland, Germany, England and the New England States, being more or less naturalized in this country as far south as New York and New Jersey. The rhizome is collected in autumn, cut into longitudinal slices and dried by artificial heat. There are several commercial varieties, and it is said that some of the drug is derived from *Valeriana sylvatica* Banks.

DESCRIPTION.—Rhizome upright, slightly ellipsoidal, more or less truncate at both ends, from 2·5 to 4 cm. long and 1 to 2 cm. in diameter, usually cut longitudinally into two, four or more pieces; externally dark brown, upper portion with circular stem and leaf-scars, the sides sometimes with short branches or stolons from 5 to 8 cm. long, with numerous roots and

few root-scars; fracture short, horny; internally light brown; odor pronounced, becoming stronger on keeping; taste somewhat aromatic.

Roots 3 to 10 cm. long, 0·5 to 1 mm. in diameter, longitudinally wrinkled; fracture brittle.

Constituents.—Volatile oil 0·5 to 2 per cent., containing, among other principles, bornyl isovalerianate, which, by the action of an oxydase, yields free isovalerianic acid, to which the odor so characteristic of the drug is due. The drug also contains two alkaloids—valerianine and chatinine; resin; tannin; and starch.

GERANIUM (Wild or Spotted Cranesbill).

The dried rhizome of *Geranium maculatum* (Fam. Geraniaceæ), a perennial herb indigenous to Canada and the Eastern and Central United States. The rhizome is collected in late summer or early autumn.

Description.—Horizontal, cylindrical or flattened, curved or bent pieces, 2·5 to 5 cm. long, 3 to 10 mm. in diameter; externally dark brown, wrinkled, upper and side portions with numerous buds or circular stem-scars, under surface with numerous root-scars; fracture short; internally light brown, bark thin, wood indistinct, pith large; odor slight; taste astringent.

Constituents.—Tannin 15 to 25 per cent., gallic acid, starch and calcium oxalate.

PODOPHYLLUM (May Apple).

The rhizome of *Podophyllum peltatum* (Fam. Berberidaceæ), a perennial herb indigenous to Eastern North America. The rhizome is collected late in summer and dried, after removal of the rootlets.

Description.—Horizontal, nearly cylindrical, flattened, sometimes branched, jointed, in pieces 3 to 8 cm. long, internodes 4 to 10 cm. long, 5 to 9 mm. in diameter, nodes 7 to 18 mm. in diameter and 5 to

12 mm. thick; externally dark brown, longitudinally wrinkled or nearly smooth, with irregular scars of bud-scales, node annulate from remains of bud-scales, upper part marked with a large circular depressed stem-scar and sometimes with buds, numerous root-scars at and near the lower portion of the nodes; fracture short; internally lemon-yellow, bark 1 mm. thick, wood yellowish, 0·5 mm. thick, pith large, white; odor slight; taste somewhat bitter and acrid.

Constituents.—Resin 4 to 5 per cent., consisting of about one-half podophyllotoxin, which is crytallizable and a powerful purgative; podophylloresin; podophyllinic acid and quercetin, to the latter of which the color is due.

Allied Plants.—The rhizome of *Podophyllum Emodi*, a plant growing on the lower slopes of the Himalayas, is larger and yields twice as much resin, more than half of which consists of podophyllotoxin.

SANGUINARIA (Bloodroot).

The rhizome of *Sanguinaria Canadensis* (Fam. Papaveraceæ), a perennial herb indigenous to the Eastern and Central United States and Canada. The rhizome should be collected in July or August and dried.

Description. — Horizontal, irregularly cylindrical, flattened, sometimes branched, 2·5 to 6 cm. long, 5 to 10 mm. in diameter; externally dark brown, slightly annulate, with few buds or stem-scars on upper surface and numerous root-scars on lower surface; fracture short and somewhat waxy; internally, bark dark brown, about 0·5 mm. thick, wood and pith with numerous reddish resin-cells; odor slight; taste bitter and acrid.

Shriveled rhizomes which are gray internally and free from starch should be rejected.

Constituents.—The drug contains a number of alka-

loids, of which the most important is sanguinarine; the yield is about 1 per cent. and it crystallizes in colorless needles and yields reddish salts with nitric and sulphuric acids; the other alkaloids include chelerythrine, which forms yellowish salts, protopine also found in opium, and β-homochelidonine which, like the last two alkaloids, is found in *Chelidonium.* In addition, the drug contains a reddish resin, several organic acids and starch.

COLCHICI CORMIS (Colchicum Corm).

The corm of *Colchicum autumnale* (Fam. Liliaceæ), a perennial bulbous plant, native of and growing in moist meadows and pastures of England, Southern and Middle Europe and Northern Africa. The corm is collected in early summer before the flowering period, deprived of the membranous, scaly coat, cut into transverse pieces, and dried at a temperature below 65° C. The commercial supply is obtained from England and Germany.

Description.—Obconical, with a groove on one side, sometimes with fragments of the flower-stalk, usually in transverse, reniform sections from 15 to 20 mm. long, about 12 mm. wide and 3 to 5 mm. thick; externally dark brown, longitudinally wrinkled; fracture short, mealy; internally light brown, with numerous circular groups of fibrovascular tissue; odor slight; taste bitter and acrid.

Constituents.—An amorphous alkaloid, colchicine, about 0.5 per cent.; two resins, considerable starch, ash about 2·5 per cent.

SCILLA (Squill).

The fleshy scales of the bulb of *Urginea Scilla* (Fam. Liliaceæ), a perennial herb indigenous to the Mediter-

ranean region. The bulbs are collected late in August, and after the removal of the membranous outer scales and the central portion, the fleshy scales are cut into transverse pieces and dried by solar or artificial heat. The article used in France is collected from bulbs having reddish scales and is obtained from Algeria and Malta.

Description.—In irregular, curved, flat, narrow, somewhat translucent pieces 3 to 5 cm. long, 5 to 8 mm. wide, 2 to 7 mm. thick, whitish, lemon-yellow or light brown, epidermis forming a thin layer, mesophyl more or less shrunken, slightly crystalline and with numerous circular projections of fibrovascular bundles; fracture brittle when dry, tough when damp; odor slight; taste bitter and acrid.

Constituents.—Squill contains a number of active principles, of which the most important are the glucoside scillitoxin, which resembles digitoxin physiologically, and scillipicrin, an amorphous, bitter principle, which is employed as a diuretic. It also contains mucilage, sugar and calcium oxalate.

III. PARTS OF ROOTS AND STEMS.

PITH, WOOD AND BARK.

The active principles are not uniformly distributed throughout all parts of the roots and stems, but are usually found in greatest amount in the bark. This is true of herbaceous plants as well as of trees and shrubs, but in most of the medicinal roots and rhizomes it has not been found economical to separate the bark from the wood, which may also contain some of the active principle. A large number of the barks alone of shrubs and trees are used medicinally. By the term bark is usually meant all that portion of the root or stem which is developed outside of the cambium,

and this is commonly differentiated into two distinct parts—one next to the cambium, in which life-processes take place, contains the greatest amount of active principles, and is known as the inner bark; another, external to this, having a greater or less development of corky layers in among more or less obliterated sieve and parenchymatious cells, is known as the outer bark. The term bark is sometimes restricted to this outer layer, but this is more or less confusing and has not been generally adopted. The term **bork** is frequently applied to the outer corky layers and the dead tissues inclosed by them. The term periderm is applied to all the tissues produced by the phellogen, the older layers of periderm being included in the bork.

In a few cases the wood alone is employed in medicine and, like the bark, may be differentiated into two layers—the one next to the cambium, in which the ascent of the cell-sap takes place, known as the **sapwood**, and another within this which may contain resinous, coloring and other substances, and denominated as **heartwood**, the latter being the part usually employed in medicine and the arts.

The pith being in the nature of a reserve layer may contain various of the carbohydrates. Sassafras pith furnishes an example of this, being used in medicine on account of the mucilage it contains.

The following artificial classification may be found of assistance in the study of the drugs of this class:

I. *Barks.*

1. With periderm.

A. Yellowish red to dark brown.

a. Fracture short.

α Aromatic odor and taste.

Dark brown . . . . Cinnamomum

Reddish brown . . . . Sassafras

β Without aromatic odor and taste.
* Usually in quills.
Few lenticels . . . . Cinchona
Numerous lenticels . . . . Frangula
** Usually in flattened or transversely curved pieces.
Inner surface reddened with alkalies . . . . Rhamnus Purshiana
Inner surface not reddened with alkalies . . . . . Viburnum Prunifolium

b. Fracture fibrous.
Tough-fibrous . . . . Gossypii Radicis Cortex
Short, fibrous . . . . Rubus

B. Grayish to grayish black.
a. Fracture fibrous.
Fracture silky-fibrous . . . . Euonymous
Fracture uneven, fibrous . . . . . . Viburnum Opulus
b. Fracture short.
α With conical cork-wings . . Southern Prickly Ash
β Cork-wings wanting.
Inner surface with acicular crystals . . . . Northern Prickly Ash
Inner surface non-crystalline . . . . Granatum

C. Greenish in color.
Fracture tough fibrous . . . . Mezereum
Fracture short, granular . . . . . . Prunus Virginiana

2. Without periderm.
A. Aromatic odor and taste . . . Cinnamomum Zeylanicum
B. Without aromatic properties
a. Surface crystalline . . . . Quillaja
b. Surface non-crystalline.
Taste astringent . . . . Quercus Alba
Taste mucilaginous . . . . Ulmus

II. *Woods*.
1. Light or bright yellow . . . . Quassia
2. Yellowish red to yellowish brown.
A. Imparts a violet or wine-color to water, Hæmatoxylon
B. Coloring matter insoluble in water, Santalum Rubrum

III. *Pith*.
Whitish, light in weight . . . . Sassafras Medulla

CINNAMOMUM (Cinnamon Bark).

The dried bark of the stem and branches of various species of *Cinnamomum* (Fam. Lauraceæ), trees indig-

enous to Tropical Asia, where they are now extensively cultivated, and from which three commercial kinds of bark are obtained: (1) Saigon Cinnamon, obtained from *Cinnamomum Loureirii* and other species cultivated in Cochin China and other parts of China and exported from Saigon; (2) Cassia Cinnamon, yielded by *Cinnamomum Cassia*, cultivated in the southeastern provinces of the Chinese Empire, and exported by way of Calcutta, and (3) Ceylon Cinnamon, collected from *Cinnamomum Zeylanicum*, indigenous to and cultivated in Ceylon.

DESCRIPTION.—**Saigon Cinnamon.**— In single quills, transversely curved or channeled pieces 6 to 30 cm. long, 1·5 to 3 cm. in diameter, bark 0·2 to 2 mm. thick; outer surface dark brown, longitudinally wrinkled, with grayish patches of foliaceous lichens, and numerous lenticels; inner surface light brown, smooth; fracture short; thick inner bark, separated from the very thin periderm by a layer of small stone cells; odor aromatic; taste mucilaginous, aromatic and pungent.

Cassia Cinnamon.—The periderm is usually removed and the bark is less aromatic.

Ceylon Cinnamon occurs in closely rolled double quills composed of numerous thin layers of the inner bark of the shoots; the odor is delicately aromatic, and the bark is less mucilaginous and pungent than the Cassia or Saigon bark.

CONSTITUENTS.—The most important constituent is the volatile oil, which in Ceylon cinnamon is delicately aromatic and amounts to from 0·5 to 1 per cent., and in Cassia and Saigon cinnamon from 1 to 2 per cent., the Saigon being most pungent and aromatic.

SASSAFRAS (Sassafras Bark).

The bark of the root of *Sassafras officinale* (Fam. Lauraceæ), a tree indigenous to Eastern North America. The bark is collected in the early spring, or autumn, deprived of the periderm, and used either in the fresh or dried condition.

Description.—In transversely curved or recurved, irregular, oblong pieces, 3 to 8 cm. long, 10 to 30 mm. in diameter, 0·5 to 3 mm. thick; outer surface light reddish brown, nearly smooth, somewhat porous; inner surface distinctly striatc, somewhat scaly; fracture short, soft, surface slightly porous; odor aromatic; taste somewhat mucilaginous, astringent and aromatic.

Constituents.—Volatile oil 5 to 9 per cent.; tannin about 6 per cent.; a reddish-brown altered tannin compound (sassafrid) about 9 per cent.; resin and starch.

CINCHONA (Cinchona Bark).

The dried bark of the stem and branches of various species of *Cinchona* (Fam. Rubiaceæ), trees indigenous to South America, but cultivated in nearly all tropical countries, from which latter the commercial supplies are obtained. There are two principal commercial varieties: (1) Red Cinchona, which is yielded by *Cinchona succirubra* Pavon, and (2) Calisaya Bark, yielded by *Cinchona Calisaya* Weddell and *Cinchona Ledgeriana* Moens. There are a number of ways of treating the bark, but the one which is principally employed, particularly in India, consists in the replacement of the bark by a covering of moss or other protecting material. The new product under these conditions is richer in alkaloids than the natural bark of the tree, and is known as "renewed bark." Not all of the original bark, however, is removed at one time, and this being also covered by the protecting material is known as "mossed bark."

Description.—**Red Cinchona.**—Usually in double quills or rolled pieces cut into lengths from 25 to 40 cm. long, 15 to 20 mm. in diameter, bark 2 to 5 mm. thick; outer surface reddish or dark brown, with grayish patches of foliaceous lichens, longitudinally wrinkled, with few usually distant transverse fissures; inner surface reddish brown, distinctly striate; fracture smooth in periderm, in inner bark with projecting bast fibers; odor distinct; taste bitter, astringent.

Calisaya Bark.—Gray or brownish gray, with numerous patches of foliaceous lichens, with brownish-black and reddish-brown apothecia and numerous transverse fissures, giving the bark a very characteristic appearance.

The trunk bark is comparatively thick, and renewed bark is comparatively smooth and uniform in color.

Constituents.—A large number of alkaloids have been isolated from this drug, of which the most important are quinine, quinidine, cinchonine and cinchonidine. The other constituents include an amorphous glucoside quinovin, which is very bitter; cinchotannic acid; quinic or kinic acid; starch; calcium oxalate, and about 3 per cent. of ash. The total alkaloids amount to about 6 or 7 per cent., of which from one-half to two-thirds is quinine in the yellow barks, whereas, in the red barks, cinchonidine exists in greater proportion.

FRANGULA (Alder Buckthorn Bark).

The dried bark of the stem and branches of *Rhamnus frangula* (Fam. Rhamnaceæ), a shrub indigenous to Europe and Northern Asia. The bark is collected in spring and kept at least one year before being used, so as to render inert the emetic principles. The applica-

tion of heat to the bark is said to produce the same result.

Description.—In single or double quills and transversely curved pieces, 2 to 20 cm. long, 1 to 3 cm. in diameter, bark 0.3 to 1 mm. thick; outer surface dark brown or purplish black, longitudinally wrinkled, with numerous lenticels 1 to 3 mm. long, and with grayish patches of foliaceous lichens and groups of light-brown or brownish black apothecia; inner surface yellowish or dark brown, smooth, longitudinally striate, and reddened by alkalies; fracture short, with projecting bast fibers in inner bark; odor slight; taste slightly bitter.

Constituents.—Frangulin, a crystalline glucoside, which yields emodin; frangulic acid, another crystalline glucoside resembling the cathartic acid of senna; rhamnoxanthin, a coloring principle; resin; tannin; starch; calcium oxalate, and 5 to 6 per cent. of ash.

RHAMNUS PURSHIANA (Cascara Sagrada).

The bark of *Rhamnus Purshiana* (Fam. Rhamnaceæ), a shrub indigenous to Northern California, Washington and Oregon. The bark is collected in spring and early summer, and kept at least one year before being used.

Description.—Usually in flattened or transversely curved pieces, occasionally in quills 2 to 10 cm. long, 1 to 3 cm. in diameter, bark 1 to 3 mm. thick; outer surface dark brown or brownish red, frequently completely covered with grayish or whitish lichens, several of which are peculiar to this bark, and with small groups of brownish apothecia, longitudinally wrinkled, sometimes with numerous lenticels 3 to 6 mm. long; inner surface light yellow or reddish brown, smooth, longitudinally striate, turning red when moistened with solutions of the alkalies; fracture short, with pro-

jections of bast fibers in the inner bark, the medullary rays one to two cells wide, forming converging groups; in cross section the inner surface of the bark indistinctly crenate; odor distinct; taste bitter, slightly acrid.

CONSTITUENTS.—Purshianin, a crystalline glucoside, which yields emodin; chrysarobin; chrysophanic acid; three resins; volatile and fixed oils; a bitter principle; tannin; starch and calcium oxalate.

ADULTERANTS.—*Rhamnus Californica*, a shrub indigenous to Southern California and the neighboring States, yields a bark which closely resembles that of Rhamnus Purshiana, but may be distinguished from it by the medullary rays, which are from 3 to 5 cells wide, and occur in more or less parallel wavy rows, and by the distinct crenation of the inner margin of the bark.

VIBURNUM PRUNIFOLIUM (Black Haw Bark).

The dried bark of the root, stem and branches of *Viburnum prunifolium* (Fam. Caprifoliaceæ), a shrub, indigenous to the Eastern and Central United States. The root bark is more highly esteemed than that of the stem and branches.

DESCRIPTION.—**Stem Bark.**—In transversely curved pieces, or irregular oblong chips, 1·5 to 6 cm. long, 0·5 to 1·5 cm. in diameter, 0·5 to 1·5 mm. thick; outer surface brownish red or grayish brown, longitudinally wrinkled, periderm occasionally exfoliated, with occasional grayish patches of foliaceous lichens and numerous lenticels; inner surface yellowish or reddish brown, longitudinally striate; fracture short, periderm brownish red, inner bark with numerous light-yellow groups of stone cells; odor slight; taste astringent and bitter.

Root Bark.—Somewhat resembling the stem bark, but smoother externally, without lichens and having fewer lenticels.

CONSTITUENTS.—A bitter, somewhat resinous principle, viburnin; valerianic (viburnic acid) and other organic acids; resin; tannin; calcium oxalate; ash about 10 per cent.

GOSSYPII RADICIS CORTEX (Cotton Root Bark).

The dried bark of the root of *Gossypium herbaceum*, and of other species of *Gossypium* (Fam. Malvaceæ), biennial or triennial shrubs indigenous to Subtropical Asia and Africa, but now cultivated in all tropical and subtropical countries.

DESCRIPTION.—In flexible, transversely curved or slightly quilled pieces, 6 to 30 cm. long, 5 to 15 mm. in diameter, bark 0·2 to 1 mm. thick; outer surface light brown, longitudinally wrinkled, with small lenticels, periderm frequently exfoliated; inner surface light brown, longitudinally striate; fracture tough, fibrous, surface light brown, tangentially striate, readily separable into fibrous layers; odor faint; taste slightly astringent and acrid.

CONSTITUENTS.—A yellowish resin; a yellow coloring principle becoming reddish and resinous with age; fixed oil; tannin; starch and calcium oxalate.

RUBUS (Blackberry Root Bark).

The bark of the root of *Rubus nigrobaccus* Bailey, and of other species of *Rubus* (Fam. Rosaceæ), perennial shrubs indigenous to the Eastern and Central United States. The bark should be collected in spring or autumn and dried.

DESCRIPTION.—In flexible, transversely curved or slightly quilled pieces 4 to 20 cm. long, 3 to 5 mm. in diameter, bark 0·2 to 2 mm. thick; outer surface light brown, longitudinally wrinkled, with few root-scars, periderm frequently exfoliated; inner surface

light brown, coarsely striate longitudinally; fracture short, fibrous, surface light brown, with oblique radiate wedges of bast; odor slight; taste astringent.

Constituents.—Tannin 10 to 15 per cent.; gallic acid about 0·4 per cent.; a bitter, crystalline glucoside villosin, somewhat resembling saponin, about 0·8 per cent.; starch; calcium oxalate; ash about 3 per cent.

EUONYMUS (Wahoo Bark).

The dried bark of the root of *Euonymus atropurpureus* (Fam. Celastraceæ), a shrub indigenous to the Central and Eastern United States and Labrador.

Description.—Usually in transversely curved pieces, occasionally in single quills, 3 to 7 cm. long, 0·5 to 1·5 cm. in diameter, bark 0·5 to 1 mm. thick; very light; outer surface light brown, somewhat wrinkled, with scaly patches of soft bark, few lenticels, root-scars and adhering roots, which frequently perforate the bark; inner surface light brown, longitudinally striate, somewhat porous, occasionally with small pieces of yellow wood adhering; fracture short, with silky projecting modified bast fibers, cork light brown, inner and middle bark somewhat tangentially striate and with irregular dark-brown bast areas; odor faint; taste bitter, acrid.

Constituents.—An amorphous, bitter principle euonymin; a crystalline glucoside resembling digitalin in its action; another glucoside atropurpurin, resembling dulcite; several resins; fixed oil; several organic acids; starch and calcium oxalate.

VIBURNUM OPULUS (Cramp Bark).

The dried bark of the stem and branches of *Viburnum Opulus* (Fam. Caprifoliaceæ), a shrub indigenous to the Northern United States and Southern Canada,

and also found growing in Europe and Asia. The cultivated variety is known as Snowball or Guelder-rose.

DESCRIPTION.—In transversely curved pieces, 6 to 20 cm. long, 1 to 2 cm. in diameter, 0·5 to 1·5 mm. thick; outer surface light brown or brownish black, longitudinally wrinkled, periderm sometimes exfoliated revealing a nearly smooth reddish-brown surface, with numerous grayish patches of foliaceous lichens, and small brownish-black apothecia and large brownish lenticels; inner surface light or reddish brown, finely striate longitudinally; fracture uneven, fibrous, surface light or reddish brown, with groups of stone cells and bast fibers; odor slight; taste astringent, bitter.

CONSTITUENTS.—A bitter, somewhat resinous principle viburnin; valerianic (viburnic acid) and other organic acids; resin; tannin; calcium oxalate; ash about 10 per cent.

XANTHOXYLUM (Prickly Ash Bark).

The dried bark of *Xanthoxylum Americanum* (Fam. Rutaceæ), a shrub or small tree indigenous from Quebec to Virginia and west to South Dakota, Nebraska and Kansas. Southern Prickly Ash bark, which is also a source of the drug, is derived from *Xanthoxylum Clava-Herculis*, a shrub which is found south from Virginia to Texas. The latter, however, appears to be less valuable medicinally.

DESCRIPTION.—**Northern Prickly Ash.**—In transversely curved pieces, occasionally in single quills, 2 to 17 cm. long, 1 to 2 cm. in diameter, 0·5 to 3 cm. thick; outer surface light brown to brownish black, with grayish patches of foliaceous lichens, numerous small black apothecia and whitish lenticels; fracture short, un-

even; inner surface light brown, finely striate longitudinally, with numerous acicular crystals, phelloderm layer dark green, inner bark with groups of converging medullary rays; odor slight; taste bitter, acrid and pungent.

Southern Prickly Ash.—Transversely curved or irregularly oblong flattened pieces, occasionally in single quills 5 to 30 cm. long, 1 to 7 cm. in diameter, 1 to 4 mm. thick; outer surface with numerous conical corky wings or their scars; inner surface free from acicular crystals.

CONSTITUENTS.—Two resins, one acrid, the other crystalline and bitter; an acrid volatile oil; a bitter, alkaloidal principle, somewhat resembling berberine, and apparently different in the two species; tannin; starch; ash about 12 per cent.

GRANATUM (Pomegranate).

The dried bark of the root and stem of *Punica Granatum* (Fam. Punicaceæ), a shrub indigenous to Northwestern India, and cultivated in the subtropical regions of the Old World.

DESCRIPTION.—**Stem Bark.**—Usually in transversely curved pieces, occasionally in single quills, 2 to 8 cm. long, 5 to 20 mm. in diameter, bark 0·5 to 2 mm. thick; outer surface yellowish brown, with grayish patches of foliaceous lichens, brownish-black apothecia and small lenticels, longitudinally wrinkled; inner surface light yellow or yellowish brown, finely striate, smooth; fracture short, smooth, phelloderm layer dark green, inner bark light brown, somewhat checkered; odor slight; taste astringent.

Root Bark.—Dark brown, with slight longitudinal patches and scales of cork, green phelloderm layer wanting, medullary rays extending nearly to the outer layer.

CONSTITUENTS.—The principal constituent is a liquid alkaloid pelletierine (punicine), from which a number of crystalline and liquid principles have been derived; the yield is from 0 35 to 0·6 per cent. in the stem bark and from 0·6 to 1·3 per cent. in the root bark; there is also present about 20 per cent. of a tannin yielding ellagic acid; starch and calcium oxalate.

MEZEREUM.

The dried bark of *Daphne Mezereum*, and of other species of *Daphne* (Fam. Thymelaceæ), shrubs indigenous to Europe and Asia, and naturalized in New England and Canada. The bark is collected in early spring; it is dried and frequently made up into small bundles, the commercial supplies being obtained from Thuringia, Southern France and Algeria.

DESCRIPTION.—In flexible double squills or somewhat flattened strips 10 to 90 cm. long, 3 to 20 mm. in diameter, bark about 0·3 mm. thick; outer surface light or dark brown, smooth, obliquely striate or wrinkled, with numerous lenticels, occasional brownish-black apothecia, and sometimes with buds or bud-scars; inner surface yellowish green, somewhat lustrous, finely striate; fracture, tough, fibrous, the dark-brown periderm readily separable from the yellowish-green cortex, inner bark yellowish green, lamellated; odor slight; taste very acrid.

CONSTITUENTS.—An acrid resin known as mezerein; a crystalline, bitter glucoside daphnin; volatile and fixed oils, and starch.

PRUNUS VIRGINIANA (Wild Black Cherry).

The bark of the stem and branches of *Prunus serotina* Ehrhart (Syn. *Prunus Virginiana* Miller) (Fam. Rosaceæ), a tree indigenous to the Eastern and Central

United States and Canada. The bark is collected in autumn, and after removal of the periderm is carefully dried and preserved.

DESCRIPTION.—Usually in transversely curved pieces 3 to 7 cm. long, 1 to 3 cm. in diameter, 0·5 to 2 mm. thick; outer surface light brown or greenish brown, somewhat glabrous, with numerous lenticels 3 to 4 mm. long; inner surface light brown, longitudinally striate and occasionally fissured; fracture short, granular; cork dark brown, thin, easily separable from the green phelloderm, inner bark porous and granular; odor of the drug distinct, and on the addition of water developing an odor of benzaldehyde and hydrocyanic acid; taste astringent, aromatic.

The bark of the trunk is dark brown and rough externally.

CONSTITUENTS.—A glucoside analogous to amygdalin or laurocerasin, a ferment which resembles emulsin, these two principles yielding by interaction hydrocyanic acid and benzaldehyde; also a glucoside which is crystalline, bitter and fluorescent; tannin about 3 per cent.; gallic acid; starch and calcium oxalate.

QUILLAJA (Soap Bark).

The bark of *Quillaja Saponaria* (Fam. Rosaceæ), a tree indigenous to Chile and Peru. The bark is removed in large pieces, deprived of the periderm and dried.

DESCRIPTION.—In flat pieces 25 to 90 cm. long, 10 to 15 cm. wide, 4 to 6 mm. thick; outer surface light brown, longitudinally striate, with numerous crystals of calcium oxalate and occasional patches of the dark-brown periderm; inner surface yellowish brown, finely wrinkled, with numerous crystals of calcium oxalate, and occasional circular depressions, conical projec-

tions or transverse channels; fracture uneven, coarsely fibrous, surface porous and with groups of white sclerenchymatous fibers; odor slight; taste acrid.

Constituents.—The drug contains two amorphous glucosides amounting to about 9 per cent., which are closely related to saponin—one soluble in alcohol and known as quillajic acid, and another nearly insoluble in alcohol and known as sapotoxin; it also contains starch and about 10 per cent. of calcium oxalate.

QUERCUS ALBA (White Oak).

The bark of *Quercus alba* (Fam. Cupuliferæ), a tree indigenous to the Eastern and Central United States and Canada. The bark is collected in spring from the branches and trunks of trees from ten to twenty-five years of age, and deprived of the periderm and dried.

Description.—In flat, irregular, more or less oblong pieces 5 to 30 cm. long, 10 to 20 mm. in diameter, 2 to 4 mm. thick; outer surface light brown, longitudinally striate, with occasional patches of dark-brown periderm; inner surface yellowish brown, coarsely striate and fissured longitudinally, and with detachable bast fibers; fracture uneven, coarsely fibrous, surface porous and dotted with groups of white sclerenchymatous cells and fibers; odor slight; taste astringent.

Constituents.—Tannin about 10 per cent.; starch and calcium oxalate.

Allied Plants.—*Quercus rober* indigenous to Europe is the source of the bark used in England and Continental Europe; the bark closely resembles that of *Quercus alba*, but the periderm is not removed; it contains from 10 to 16 per cent. of tannin, besides gallic and ellagic acids. *Quercus velutina*, or black oak, yields the quercitron bark, which resembles that of *Quercus alba* but is reddish brown, and tinges the saliva yel-

lowish; it contains besides tannin a yellow glucosidal principle quercitrin, which yields quercetin, a yellow coloring principle.

ULMUS (Slippery-Elm Bark).

The bark of *Ulmus fulva* (Fam. Ulmaceæ), a tree indigenous to the Eastern and Central United States and Canada. The bark is collected in spring, deprived of the periderm and dried, the commercial article coming chiefly from Michigan.

DESCRIPTION.—In flat oblong pieces about 30 cm. long, 10 to 15 cm. in diameter, 3 to 4 mm. thick; outer surface light brown, longitudinally wrinkled and furrowed and with occasional dark-brown patches of periderm; inner surface yellowish or light brown, more or less uniformly wrinkled longitudinally; fracture fibrous, surface light brown, porous from large mucilage cells; odor slight, distinct; taste mucilaginous.

CONSTITUENTS.—The principal constituent is mucilage; it also contains starch and calcium oxalate.

ALLIED PLANTS.—*Ulmus campestris*, or European elm, yields a bark which is dark brown, and contains, besides mucilage, a bitter principle and tannin.

QUASSIA.

The wood of *Picræna excelsa* (Fam. Simarubaceæ), a tree indigenous to Jamaica. The trees are felled and cut into billets. The latter are exported and afterward manufactured into "quassia cups," the shavings constituting the drug of commerce. The market supply of this drug was at one time almost exclusively obtained from *Quassia amara* (Fam. Simarubaceæ), a small tree indigenous to Northern South America, the wood being exported from Surinam and known as

Surinam Quassia; this is the variety used in continental Europe.

Description.—Usually in raspings, light or bright yellow, medullary rays two to five cells wide in transverse section, the cells containing tetragonal prisms or cryptocrystalline crystals of calcium oxalate; fracture fibrous; odor slight; taste bitter.

Surinam Quassia ussually occurs in small billets; the medullary rays are one cell wide in transverse section, and calcium oxalate crystals are wanting.

Constituents.—Jamaica quassia contains two crystalline bitter principles—α-picrasmin and β-picrasmin; it also contains a crystalline alkaloidal principle which gives a blue fluorescence in acidified alcoholic solution.

Surinam quassia contains one or more bitter principles, which are related to the picrasmins of Jamaica quassia, and which are known as quassiins.

HÆMATOXYLON (Logwood).

The heartwood of *Hæmatoxylon Campechianum* (Fam. Leguminosæ), a tree indigenous to Central America, and naturalized in the West Indies. Much of the commercial logwood being used for dyeing is allowed to ferment, but it is the unfermented wood that should be used for medicinal purposes.

Description.—Usually in small chips, externally reddish brown, freshly cut surface dark yellowish red, in transverse section slightly radiate and with numerous alternate yellowish and reddish concentric rings, medullary rays four cells wide; fracture hard, fibrous; odor slight; taste sweet, astringent, imparting to water a violet or wine color.

Constituents. — A colorless crystalline principle, hæmatoxylin, 10 to 12 per cent.; it is easily oxidized to hæmatein, which has a green, metallic luster and is

characteristic of the fermented wood. The drug also contains volatile oil, resin, tannin and calcium oxalate.

SANTALUM RUBRUM (Red Saunders).

The heartwood of *Pterocarpus santalinus* (Fam. Leguminosæ), a tree indigenous to the southern part of the Indian Peninsula, and cultivated in the Southern Philippines, Ceylon and Southern India, the chief supplies coming from Madras.

DESCRIPTION.—Usually in small chips or coarse powder, red or brownish red, in transverse section slightly radiate, with numerous alternate lighter and darker concentric rings, medullary rays one cell wide; fracture hard, fibrous; inodorous; taste slight.

CONSTITUENTS.—A red crystalline coloring principle santalin (santalic acid), which is soluble in alcohol but not in water, and several colorless crystalline principles.

SASSAFRAS MEDULLA (Sassafras Pith).

The pith of young stems and branches of *Sassafras officinale* (Fam. Lauraceæ), a tree indigenous to Eastern North America. The pith is collected late in autumn, after frost, and dried.

DESCRIPTION.—Cylindrical, cut longitudinally into pieces 2 to 10 cm. long, about 5 to 7 mm. in diameter, or in irregular somewhat curved or angled pieces; very light; externally whitish or light brown, occasionally with small fragments of wood adhering; consisting for the most part of parenchyma cells with thin walls having numerous simple pores and swelling perceptibly in water; fracture short; slight odor of sassafras; taste mucilaginous.

The mucilage obtained from sassafras is not precipitable by alcohol.

CONSTITUENTS.—The principal constituent is the mucilage; it also contains a trace of volatile oil.

IV. FLOWERS.

In quite a number of plants, particularly the Labiatæ and Compositæ, principles having medicinal and other properties occur in relatively large amount in the flowers. These principles are, as a rule, more or less volatile and aromatic, many of them being used in perfumery and for flavoring, as well as for medicinal purposes.

KEY FOR THE STUDY OF FLOWERS.

I. *Flower Buds.*
   1. Entire.
      Reddish brown . . . . Caryophyllus
      Yellowish green or greenish brown composite heads . . . . Santonica
   2. Petals only.
      Rose colored . . . . Rosa Gallica

II. *Expanded Flowers.*
   1. Flower heads.
   A. Tubular and ligulate flowers.
      Ligulate flowers, bright yellow . . . . . Arnicæ Flores
      Ligulate flowers, whitish . . . . Matricaria
   B. Chiefly ligulate flowers.
      Whitish globular heads . . . . Anthemis
   2. Ligulate florets only.
      Corolla bright yellow . . . . Calendula

III. *Entire Inflorescence.*
      Flowers pistillate, reddish brown . . . . Cusso

CARYOPHYLLUS (Cloves).

The flower-buds of *Jambosa Caryophyllus* [Syn. *Eugenia caryophyllata* Thunberg and *E. aromatica* (Linne) O. Kuntze] (Fam. Myrtaceæ), an evergreen-tree indigenous to the Molucca Islands, where it is also cultivated, as well as in Zanzibar, Ceylon and Java. The flower-buds are collected, dried in the sun or artificially, the color changing from a crimson to a brownish. The chief commercial supplies come from Amboyna, Penang and Zanzibar, the former two varieties being preferred.

Description.—About 15 mm. long, 3 to 6 mm. in diameter, more or less cylindrical, dark brown, calyx united with the ovary, with four incurved teeth about 3 mm. long, surmounted by a light-brown globular head consisting of four petals which are imbricated, punctate and alternate with the calyx teeth; stamens numerous, crowded and incurved, style one, ovary two-celled, with numerous ovules; odor and taste strongly aromatic.

Constituents.—The chief constituent is the volatile oil, which occurs to the extent of 15 to 20 per cent., and consists of caryophyllene and eugenol, the latter constituting 80 or 90 per cent. of the oil; cloves also contain an odorless, tasteless and crystalline principle caryophyllin; vanillin; eugenin (isomeric with eugenol or eugenic acid) which resembles caryophyllin but becomes reddish with nitric acid; gallo-tannic acid; calcium oxalate, and 5 to 7 per cent. of ash.

Clove stalks are less aromatic and yield from 4 to 7 per cent. of volatile oil. The so-called mother of cloves is the nearly ripe fruit of *Jambosa Caryophyllus;* the fruit is an ovoid brownish berry about 25 cm. long; it is less aromatic than cloves and contains starch.

SANTONICA (Levant Wormseed).

The flower-heads of *Artemisia Cina* (Fam. Compositæ), a small shrub indigenous to the deserts in Northern Turkestan. The flower-heads are collected in July and August before they expand, and carefully dried and preserved.

Description.—Oblong or ellipsoidal, 2 to 4 mm. long, 1 to 1·5 mm. in diameter; involucre ovoid, consisting of twelve to eighteen closely imbricated ovate or ovate-lanceolate, glandular, somewhat shiny bracts, about 2 mm. long, with a yellowish green or greenish

brown middle portion and whitish margin; receptacle flat, naked, with three to six unexpanded, perfect tubular flowers about 1·5 mm. long and completely inclosed by the upper bracts; ovary oblong; pappus wanting; odor distinct; taste aromatic.

Constituents.—A crystalline neutral principle, santonin, which occurs to the extent of 2 to 3·5 per cent., just before the expansion of the flowers; volatile oil about 2 per cent.; a crystalline principle artemisin, which is apparently oxysantonin; and a resin.

ROSA GALLICA (Red Rose).

The petals of *Rosa Gallica* (Fam. Rosaceæ), a shrub indigenous to Southern Europe and probably Western Asia, and extensively cultivated in all parts of the world. The petals are obtained from cultivated plants before the expansion of the flower, the lower clawed portion usually being removed; they are used fresh or they are carefully dried and preserved. The chief supply of the drug is from the south of France.

Description.—Imbricated, numerous, usually in small cones; petals broadly ovate, the upper part rose-colored and retuse, the lower part brownish red, more or less rounded, acute or truncate, with numerous papillæ and fine longitudinal veins; texture velvety; odor agreeable; taste astringent and slightly bitter.

Constituents.—Volatile oil in small amount; a yellow, crystalline glucoside quercitrin, which yields, on decomposition, quercetin; tannin and gallic acid.

Allied Plants.—The petals of *Rosa centifolia* are collected after the expansion of the flowers and dried; they are brownish and not so fragrant as those of *Rosa gallica.* The flowers of cultivated plants of *Rosa Damascena* yield the commercial volatile oil of rose.

ARNICÆ FLORES (Arnica Flowers).

The dried expanded flower-heads of *Arnica montana* (Fam. Compositæ), a perennial herb indigenous to Central Europe, and growing in the mountains of Switzerland, Asia and Western North America. In Germany, on account of the involucre and receptacle being injured by the larvæ of the insect *Trypeta arnicivora*, these parts are removed and the flowers alone used.

Description.—Sub-globular or truncate-conical, about 15 mm. in diameter; involucre campanulate, bracts twenty to twenty-four in two rows, linear-lanceolate, dark green, pubescent, glandular; receptacle solid, slightly convex, deeply pitted, bristly hairy; ray or ligulate flowers fourteen to twenty, about 2 cm. long, bright yellow, pistillate, corolla three-toothed, seven to twelve-veined, very pubescent and glandular below, ovary about 4 mm. long, erect, pubescent and glandular, pappus consisting of a single row of about thirty rough bristles; disk or tubular flowers forty or fifty, about 17 mm. long, perfect, bright yellow, corolla five-toothed, very glandular and pubescent below, ovary about 6 mm. long, glandular and pubescent; achene spindle-shaped, dark brown, finely striate, glandular-pubescent and surmounted by a pappus of white barbed bristles about 7 mm. long; odor distinct; taste bitter and acrid.

Constituents.—A bitter crystalline principle, arnicin, and volatile oil 0·5 to 1 per cent.

Adulterants.—Arnica flowers are not infrequently adulterated with the flowers of various other Compositæ, or even entirely substituted by them; of these may be mentioned the flowers of *Calendula officinalis* (see Calendula); species of *Inula*, the achenes of which are glabrous; and *Tragopogon pratensis*, the ligulate flowers of which are five-toothed at the apex.

MATRICARIA (Wild or German Chamomile).

The flower-heads of *Matricaria Chamomilla* (Fam. Compositæ), an annual herb indignous to Europe and Western Asia, and naturalized in Australia and certain parts of the United States, including New York and Pennsylvania. The flower-heads are collected, when they are mature or expanded, from wild plants.

Description.—Rounded, conical, 3 to 10 mm. broad; peduncle 0·5 to 3·5 cm. long, nearly glabrous; involucre hemispherical, scales twenty to thirty, imbricated, oblanceolate, the middle portion brownish, margin whitish, pubescent; receptacle ovoid, becoming conical and hollow, deeply pitted, naked, 3 to 5 mm. high, about 1·5 mm. in diameter; ray or ligulate flowers twelve to eighteen, pistillate, about 12 mm. long, corolla white, three-toothed, four-veined; disk or tubular flowers numerous, yellowish, perfect, oblong, small, somewhat glandular, about 2·5 mm. long; achenes somewhat obovoid, about 0·5 mm. long, faintly three to five-ribbed; pappus none, or forming a membranous crown; odor distinct; taste aromatic and bitter.

Constituents.—The active principles resemble those found in anthemis; the amount of volatile oil however is less, only about 0·25 per cent. being present, and while similar to is not identical with that of anthemis.

Adulterants.—Matricaria is not infrequently adulterated with the flower-heads of other Compositæ, as *Anthemis arvensis.* In these, the peduncle is pubescent; the receptacle solid and conical; involucral scales lanceolate; chaff-scales lanceolate or lanceolate-acuminate, about 4 mm. long. In *Anthemis Cotula* the peduncles are slightly pubescent and the ligulate flowers neutral.

ANTHEMIS (Roman or English Chamomile).

The expanded flower-heads of *Anthemis nobilis* (Fam. Compositæ), a perennial herb indigenous to Southern and Western Europe and cultivated in Belgium, England, France, Germany, Hungary and the United States, and naturalized from Rhode Island west to Michigan and south to Delaware. The flowers are collected from cultivated plants, and dried by artificial means, the principal supplies coming from Belgium, France and Saxony.

Description.—Globular, compressed, 1·5 to 2 cm. in diameter; involucre hemispherical, with two or three rows of imbricated, nearly equal, somewhat elliptical, very pubescent scales, having a greenish middle portion and a yellowish margin; receptacle conical or convex, solid, 3 to 4 mm. high, occasionally hollow, and sometimes containing the larvæ of an insect; chaff-scales resembling the involucral scales, about 2 mm. long; ligulate flowers numerous, 6 to 10 mm. long, corolla white, three-toothed, four-nerved, ovary about 1 mm. long, glandular, style slender, stigma bi-cleft; tubular flowers few or none, lemon-yellow, perfect; achene oblong, pappus none; odor distinct; taste aromatic and bitter.

Constituents.—Volatile oil, which is bluish-green when fresh, about 1 per cent.; a bitter crystalline principle anthemic acid; resin and tannin.

CALENDULA (Marigold).

The ligulate florets of *Calendula officinalis* (Fam. Compositæ), an annual herb indigenous to Southern Europe and the Levant, and widely cultivated as a garden plant. The flowers are collected when fully expanded and dried.

Description.—Florets usually without the ovary;

corolla bright yellow, 15 to 25 mm. long, one to three-toothed, four or five-veined, margin nearly entire, tube sometimes inclosing the remains of a filiform style and bifid stigma, pubescent on the outer surface; ovary oblong, about 0·5 mm. long, pubescent; odor distinct; taste faintly saline, slightly bitter.

Allied Plants.—The florets of various other Compositæ are sometimes admixed with or substituted for Calendula, of which the following may be mentioned together with their principal distinguishing characteristics: The ligulate corolla of *Taraxacum officinale* is five-toothed; the ligulate corolla of *Arnica montana* is seven to twelve-veined; the ligulate corolla of *Tussilago Farfara* is linear, about 13 mm. long and about 0·3 mm. broad, apex acute, entire; and the ray florets of *Tagetes patula* are somewhat spatulate, about 20 mm. long and 10 mm. wide, sometimes marked with darker stripes and have undulate margins.

Constituents.—Volatile oil; an amorphous bitter principle; a gummy substance calendulin, and resin.

CUSSO (Kousso, Brayera).

The pistillate flowers of *Hagenia Abyssinica* (Fam. Rosaceæ), a tree indigenous to Northeastern Africa, and cultivated in Abyssinia. The entire panicles are collected after fertilization and dried in the sun; the flowers are sometimes stripped from the panicles, or the panicles are made into rolls.

Description.—In more or less cylindrical rolls about 30 cm. long and about 5 cm. in diameter; branches cylindrical, flattened, about 3 mm. in diameter, longitudinally furrowed or wrinkled, internodes about 15 mm. long, externally light brown, tomentose, glandular, internally, cork yellowish brown, fibro-vascular bundles in distinct wedges, bast and wood

fibers yellow, distinct, pith large, yellowish brown; flowers subtended by two ovate, reddish, pubescent and glandular bracts, pedicel short, calyx turbinate, pubescent below, consisting of two alternate whorls of four or five obovate or oblanceolate sepals, the outer ones 10 or 12 mm. long, obtuse, entire, purplish veined, persistent and becoming much elongated in the fruit, the inner about 3 to 4 mm. long, becoming shriveled and bent over the young fruit; carpels two, ovary about 1 mm. long, the upper portion very pubescent, styles exserted, about as long as the ovary, stigma large, compressed, with prominent papillæ; fruit an ovoid achene, about 2 mm. in diameter, inclosed by the remains of the calyx; odor slight; taste bitter and acrid.

Constituents.—The active principle appears to be an amorphous substance cosotoxin; several other principles have been isolated, but their real nature and properties have not been fully determined; the drug also contains cosin (koussein); about 6 per cent. of a resinous principle; volatile oil; tannin about 24 per cent., and about 5 per cent. of ash.

Adulterants.—Sometimes the flowers are stripped from the panicles and sold as such, when the drug is known as "loose cusso;" in this condition they are likely to be admixed with the staminate flowers, which are readily distinguishable and inferior in quality.

V. FRUITS.

The fruits of a large number of plants are used in medicine; these vary greatly, not only in their medicinal properties, but also in their botanical origin. The active principles of fruits vary according to their stage of development, so that fruits which contain relatively large amounts of poisonous principles when green or immature, may be quite free therefrom

and even edible when they are ripe. It is for this reason that by far the larger number of medicinal fruits are collected in the fully developed but unripe condition.

KEY FOR THE STUDY OF FRUITS.

I. *Entire Fruits.*

1. Not more than 10 mm. long (exclusive of the stalk).

A. Cremocarps.

a. Hairy.

Slender pedicel, 4–10 mm. long . . . . Anisum

b. Nearly smooth.

α. Mericarps more or less united.

Nearly globular . . . . Coriandrum

Oblong or cylindrical . . . . Fœniculum

β. Mericarps usually separate.

Odor and taste aromatic . . . . Carum

Odor peculiar . . . . Conium

B. Dry drupes.

a. Hairy.

Pericarp reddish . . . . Rhus Glabra

b. Not hairy.

α. Coarsely reticulate.

Slender pedicels, 5–7 mm. long . . . . . . Cubeba

Stalk wanting . . . . Piper

β. Not reticulate.

Inferior drupe . . . . Pimenta

2. Between 10 and 40 mm. long.

Berry . . . . Capsicum

Capsule . . . . Cardamomum

Drupe . . . . Prunum

Strobile . . . . Humulus

3. More than 40 mm. long.

Berry . . . . Colocynthis

Indehiscent legume . . . . Cassia Fistula

Pod . . . . Vanilla

Syconium . . . . Ficus

II. *Parts of Fruits.*

1. Outer rind.

A. Fresh.

From sweet oranges . . . . Aurantii Dulcis Cortex

From lemons . . . . Limonis Cortex

B. Dried.

In quarters or in ribbon-like bands, ... Aurantii Amari Cortex

2. Pulp.

Blackish-brown masses or cakes . . . . . . Tamarindus

3. Secreting Hairs.

A glandular powder . . . . Lupulinum

ANISUM (Anise).

The ripe fruit of *Pimpinella Anisum* (Fam. Umbelliferæ), an annual herb indigenous to Asia Minor, Egypt and Greece, and cultivated in South America, Germany, Spain, Italy and Southern Russia. The drug is derived from cultivated plants, and that obtained from Spain, and known as "Alicante Anise," is preferred.

Description.—Mericarps usually coherent and attached to a slender pedicel 4 to 10 mm. long; cremocarp ovoid, laterally compressed, 4 to 5 mm. long, about 2 mm. in diameter, externally greenish brown or grayish green, with ten yellowish filiform primary ribs, finely pubescent, apex with a ring-like disk and two projecting divergent styles about 0.5 mm. long, internally yellowish brown, with a slender carpophore attached to each mericarp, the latter in section irregularly plano-convex, slightly concave on the commissural side and usually with two large vittæ on each face, dorsal surface with thirty to forty vittæ; seed somewhat reniform in section, closely cohering to the pericarp, with a small embryo at the upper end of the reserve layer; odor and taste pleasantly aromatic.

Constituents.—Volatile oil (1 to 3 per cent.) consisting of about 80 to 90 per cent. of anethol; fixed oil 3 to 4 per cent.; calcium oxalate; ash about 7 per cent.

Russian aniseed is used chiefly for the manufacture of the volatile oil.

ADULTERANTS.—Italian aniseed is sometimes contaminated with conium, and the fruits of some of the grasses and rushes as well.

CORIANDRUM (Coriander).

The fruit of *Coriandrum sativum* (Fam. Umbelliferæ), an annual herb indigenous to the Mediterranean and Caucasian region, naturalized in the temperate parts of Europe, and cultivated there and in Africa and India. The fruit is collected when full grown from cultivated plants, from which it is separated by thrashing, and dried. The fruits from plants grown in Russia and Thuringia are preferred.

DESCRIPTION.—Mericarps usually coherent; cremocarp nearly globular, 4 to 5 mm. in diameter, externally light brown or rose-colored, with ten prominent, straight, longitudinal primary ribs, between which are faint, somewhat undulate secondary ribs, apex with five calyx teeth and a conical stylopodium about 0·5 mm. long, internally with a slender carpophore attachep to each mericarp, the latter grayish-purple, concavo-convex, with two vittæ on the commissural surface; seed plano-convex, with a small embryo at the upper end of the reserve layer; odor and taste aromatic.

CONSTITUENTS.—Volatile oil about 1 per cent.; fixed oil about 13 per cent.; tannin; calcium oxalate; ash about 5 per cent.

The unripe fruits are said to yield a volatile oil that has a fetid odor, which it loses on keeping.

FŒNICULUM (Fennel).

The fruit of *Fœniculum vulgare*, and of the var. *dulce* (Fam. Umbelliferæ), perennial herbs indigenous to the Mediterranean region of Europe and Asia, and cultivated in France, Galicia, Germany, Roumania,

Russia, India, Japan, etc. The fruit is collected when ripe and dried. That obtained from plants cultivated in Germany (Saxony and Thuringia), Galicia and Russia is preferred.

DESCRIPTION.—Mericarps usually separated; cremocarp oblong or nearly cylindrical, straight, 4·5 to 8 mm. long, 2 to 3 mm. in diameter, externally yellowish-green, apex with a somewhat depressed disk, and a conical stylopodium about 0·5 mm. long, each mericarp with five prominent, yellowish, slightly winged primary ribs, internally somewhat greenish brown, with a slender carpophore attached to each mericarp, the latter unequally five-angled in cross section, the commissural surface slightly grooved and with two vittæ, dorsal surface with a single vitta between each of the primary ribs; seed irregularly plano-convex, with a small embryo at the upper end of the reserve layers; odor and taste aromatic.

CONSTITUENTS.—Volatile oil 2 to 5 per cent., containing about 20 per cent. of fenchone which gives the fruit its characteristic odor and taste; fixed oil about 12 per cent.; calcium oxalate, and about 7 per cent. of ash.

The sweet or Roman fennel, obtained from plants cultivated in Southern France, has longer and somewhat curved mericarps, and yields about 2 per cent. of oil which does not contain fenchone.

CARUM (Caraway).

The fruit of *Carum Carvi* (Fam. Umbelliferæ), a biennial herb indigenous to Europe and Asia, and cultivated in England, Germany, Holland, Norway, Russia, Sweden and the United States, being naturalized in the Northern United States and parts of Canada. The plants are cut when the fruits are ripe, the latter being

separated by thrashing. The fruits from plants grown in Holland are preferred.

Description.—Mericarps usually separated; cremocarp oblong, laterally compressed, 4 to 6 mm. long, 2 to 3 mm. in diameter, externally dark brown, surmounted by a small somewhat globular stylopodium and five minute calyx teeth; primary ribs ten in number, filiform, yellowish, between each of which are slight, secondary ribs; internally dark brown, mericarps curved, narrowed at both ends, and with a slender carpophore attached to each, the latter five-angled in cross section, the commissural surface with two vittæ, the dorsal surface with four vittæ between each of the primary ribs; seeds irregularly oblong in section, with a small embryo at the upper end of the reserve layer; odor and taste aromatic.

Constituents.—Volatile oil from 5 to 7 per cent.; fixed oil; tannin, calcium oxalate, and 5 to 8 per cent. of ash.

CONIUM (Poison Hemlock).

The fruit of *Conium maculatum* (Fam. Umbelliferæ), a biennial herb indigenous to Europe, and naturalized in North and South America and in various parts of Asia. The fruit is collected when full grown but still green from wild plants, carefully dried and preserved.

Description.—Mericarps usually separated; cremocarp broadly ovoid, slightly compressed laterally, 3 to 4 mm. long, about 2 mm. in diameter, with a pedicel 3 to 5 mm. long, externally grayish green, with ten straight more or less crenate yellowish ribs, stylopodium depressed, internally greenish brown, with a slender carpophore attached to each mericarp, the latter five-angled in cross section and without any

vittæ; seeds reniform, with a deep furrow on the commissural side, and with a small embryo at the upper end of the reserve layer; odor distinct; taste slight.

CONSTITUENTS.—The most important constituent is the liquid alkaloid coniine, which exists to the extent of 0·5 to 3 per cent.; the drug also contains methylconiine and conhydrine, volatile oil, fixed oil, starch, calcium oxalate, and yields about 6 per cent. of ash.

Coniine is naturally combined in the drug with organic acids, from which it is liberated on treatment with alkalies, and is distinguished by its disagreeable odor.

RHUS GLABRA (Sumach Berries).

The fruit of *Rhus glabra* (Fam. Anacardiaceæ), a shrub indigenous to Canada and the United States, extending as far west as Arizona.

DESCRIPTION.—Drupe dry, superior, nearly globular, flattened, 3 to 4 mm. in diameter, 2·5 mm. thick, and with a slender peduncle about 2 mm. long; reddish externally, very pubescent, apex with a scar and with the remains of the style, base occasionally with the five-cleft calyx; endocarp smooth, shiny, light red; one-celled, one-seeded; seed campylotropous, dark brown, smooth, hilum marked by a distinct scar, reserve layer wanting, embryo curved; inodorous; taste acidulous and astringent.

CONSTITUENTS.—Tannic acid 5 to 25 per cent.; gallic acid, and acid calcium and potassium malates.

CUBEBA (Cubeb Berries).

The fruit of *Piper Cubeba* (Fam. Piperaceæ), a woody climber indigenous to Borneo, Java and Sumatra, where it is apparently also cultivated. The fruit is gathered when full grown but still green, and carefully

dried in the sun, the commercial supplies being shipped from Batavia and Singapore.

Description.—Drupe dry, superior, globular, 4 to 6 mm. in diameter, with a straight slender peduncle 5 to 7 mm. long; externally dark brown, coarsely reticulate, apex with remains of three to four stigmas; pericarp about 0·3 mm. thick; internally light brown, smooth, oily, one-celled, one-seeded; seed orthotropous, broadly ovoid, 4 to 5 mm. in diameter, reddish brown, straight, mostly smooth on one side where it lies against the pericarp, chalazal end with a broad scar, micropyle with a slight depression, a small embryo at the upper end of the reserve layer; odor distinct; taste aromatic and pungent.

Constituents.—Volatile oil 10 to 15 per cent.; several resins amounting to about 3 per cent., one of which is acrid and one a so-called indifferent resin; cubebic acid 1 to 3 per cent., this being colored reddish with sulphuric acid; starch, and about 6 per cent. of ash.

Adulterants.—The fruits of other species of *Piper* sometimes find their way into market; these are grayish in color, or somewhat bitter, and do not give a wine-colored reaction with sulphuric acid. Not infrequently a considerable amount of the rachis is present and this contains a relatively small amount of the active principles.

PIPER (Black Pepper).

The fruit of *Piper nigrum* (Fam. Piperaceæ), a woody, perennial climber indigenous to Southern India and cultivated in the East Indies, West Indies and other tropical countries. The fruit is gathered when full grown, removed from the rachis and dried in the sun. The commercial supplies are obtained from plants cultivated in Java, Sumatra and other islands of the Malay

Archipelago, the principal points of export being Batavia and Singapore.

DESCRIPTION.—Drupe dry, superior, nearly globular, 4 to 6 mm. in diameter, epicarp very thin, easily separable from the sarcocarp; externally blackish brown, coarsely reticulate, apex with remains of sessile stigma, base with scar of pedicel, sarcocarp and endocarp dark brown and with numerous longitudinal veins; seed orthotropous, broadly ovoid, 4 to 5 mm. in diameter, externally reddish brown, micropylar end pointed, chalazal end marked by a small scar; internally yellowish green, embryo small, frequently more or less shriveled and situated near the end of the fruit and in the center of the reserve layer; odor aromatic; taste aromatic and pungent.

CONSTITUENTS.—Volatile oil 1 to 2 per cent.; a neutral principle piperin 5 to 8 per cent.; piperidine a colorless liquid alkaloid, about 0·5 per cent.; a pungent resin chavicin; starch; tannin; proteids about 10 per cent.; ash about 5 per cent.

ALLIED PRODUCTS.—When the ripe fruits of *Piper nigrum* are deprived of the outer part of the pericarp they constitute the so-called "white pepper," which differs from the official in being nearly smooth, light yellow and less aromatic and pungent.

Piper officinarum, a shrub indigenous to the Malay Archipelago, yields the so-called "long pepper," which consists of the entire spikes of the immature fruit; the spikes are cylindrical, from 2·5 to 4 cm. long, about 5 mm. thick, of a grayish-black color, and the drupes are less aromatic and pungent than the official pepper.

PIMENTA (Allspice).

The fruit of *Pimenta officinalis* (Fam. Myrtaceæ), a tree indigenous to the West Indies, Mexico, Central

America and Venezuela, where it is also cultivated, especially in Jamaica. The panicles are collected when the fruit is full grown but still green, and dried in the sun, the fruit being subsequently separated.

DESCRIPTION. — Drupe dry, inferior, subglobular, 5 to 7 mm. in diameter; externally dark brown, glandular-punctate; apex with four minute calyx teeth or forming a minute ring and surrounding the remnants of the somewhat depressed style; base with scar of pedicel or occasionally with a pedicel 4 to 6 mm. long; pericarp about 1 mm. thick; internally light brown, two-celled, two-seeded, dissepiments thin; seeds campylotropous, plano-convex, slightly reniform, about 4 mm. long and about 3 mm. thick, externally reddish-brown, smooth, somewhat wrinkled, shiny, internally dark brown, reserve layer wanting, embryo curved; odor and taste aromatic.

CONSTITUENTS.—Volatile oil (3 to 4 per cent.) consisting of about 60 per cent. of eugenol; resin; an acrid fixed oil about 6 per cent.; tannin; starch; calcium oxalate; ash about 4 per cent.

CAPSICUM (Cayenne Pepper, African Pepper).

The dried ripe fruit of one or more species of *Capsicum*, probably *Capsicum fastigiatum* Blume, *Capsicum frutescens* Linné, and *Capsicum minimum* Roxburgh (Fam. Solanaceæ), shrubs indigenous to Southern India, and extensively cultivated in Tropical Africa and America, and Japan. The commercial supplies are obtained from cultivated plants in Natal, Sierra Leone, Zanzibar and Japan.

DESCRIPTION.—Oblong, conical, laterally compressed, 1·5 to 4 cm. long, 6 to 10 mm. in diameter, with an inconspicuous five-toothed calyx and sometimes a slender straight pedicel about 15 mm. long; externally yel-

lowish or brownish red, glabrous, shiny, somewhat translucent, more or less shriveled; apex acute, base somewhat rounded; pericarp coriaceous, thin; internally with two or three distinct longitudinal ridges, longitudinally striate, two or three-celled, carpels united below, dissepiments thin; seeds 10 to 20, campylotropous, irregularly circular or obovate, flattened, pointed, about 3 to 4 mm. in diameter, 0·5 mm. thick, edge slightly thickened, embryo curved, imbedded in the endosperm; odor distinct; taste of pericarp pungent, of dissepiments, very pungent.

CONSTITUENTS.—A crystalline, pungent principle, capsaicin (contained principally in the dissepiments), about 0·02 per cent.; two non-pungent alkaloids—one volatile and the other crystalline; volatile oil; resin; starch; ash 4 to 6 per cent.

ALLIED PLANTS.—Garden or pod-pepper, also known as "chillies," is the product of *Capsicum annuum*, an herb extensively cultivated in Hungary, Italy and Spain, and this kind is recognized by the German Pharmacopœia.

CARDAMOMUM (Cardamom).

The fruit of *Elettaria Cardamomum* (Syn. *E. repens*) (Fam. Zingiberaceæ), a perennial herb indigenous to Southern India, and cultivated near the Malabar Coast and in Ceylon. The fruit is gathered in autumn—either the entire spike when some of the fruits have matured, or the full-grown fruits are cut from the rachis in succession as they ripen; they are bleached by exposure to the sun, sometimes sulphurous acid or steam being also used, after which they are dried and freed from extraneous matter. Seeds which have been discharged from the capsules are inferior to those which have been retained. The commercial varieties are known as Malabar and Mysore Cardamom.

Description.—**Malabar Cardamom.**—Capsule loculicidally dehiscent, broadly ellipsoidal, occasionally ovoid, more or less triangular in transverse section, 10 to 17 mm. long, 6 to 8 mm. in diameter, pericarp about 0·5 mm. thick; externally light brown or faintly pink, apex slightly beaked, and with remnants of style, base rounded, with scar of stalk, longitudinally striate, three-grooved, three-valved, three-celled, dissepiments thin; seeds fifteen to eighteen in number, anatropous, irregularly angular, inclosed in a thin membranous aril, about 3 mm. long, externally dark reddish brown, deeply wrinkled, embryo small, straight, endosperm and perisperm distinct; odor aromatic; taste aromatic, pungent.

Mysore Cardamom. Ovoid, somewhat oblong, white or very light brown, 12 to 20 mm. long, 7 to 9 mm. in diameter, nearly smooth or faintly striate longitudinally; seeds nine to twelve—less pungent than those of Malabar Cardamom.

Constituents.—Volatile oil about 5 per cent.; fixed oil 10 per cent.; starch about 3 per cent.; calcium oxalate; ash 4 to 6 per cent.

Allied Plants.—Ceylon Cardamom is obtained from wild plants of *Elettaria major.* The capsules are 20 to 30 mm. long and about 10 mm. in diameter, distinctly triangular in transverse section, deeply striate longitudinally and slightly pubescent. The seeds are bitter and less aromatic.

PRUNUM (Prune).

The fruit of *Prunus domestica,* and of the var. *Juliana* (Fam. Rosaceæ), a tree indigenous to Southern Europe, and largely cultivated in Southern France and Germany. The fruit is collected when ripe and partially dried by artificial means, or completely dried

in the sun. The fruit exported from Bordeaux is of superior quality.

DESCRIPTION. — Drupe, superior, fleshy, ellipsoidal, more or less compressed, 3·5 to 4 cm. long, about 3 cm. broad; externally brownish black, glabrous, wrinkled, with two faint lines indicating the dorsal and ventral sutures, apex with a slight scar from the remains of the style, base with a depressed stalk-scar 3 to 5 mm. in diameter, sarcocarp yellowish brown, fleshy, somewhat stringy, 1·5 cm. thick; taste sweet and acidulous; endocarp ellipsoidal, flattened about 2 mm. thick, externally dark brown, reticulate, with a groove on one side, frequently extending nearly around the edge, internally light brown, smooth, one-celled, one-seeded, occasionally two-seeded; seed about 2 cm. long, 8 mm. wide, 5 mm. thick, closely resembling Bitter Almond (see Amydala Amara).

CONSTITUENTS.—Sugar 25 to 40 per cent.; organic acids, as malic, tartaric, etc., about 2 per cent.

HUMULUS (Hops).

The fruit of *Humulus Lupulus* (Fam. Moraceæ), a perennial herbaceous climber indigenous to Europe, Asia and North America, and extensively cultivated in various parts of Europe, the United States, South America and Australia, where it is also naturalized. Hops are collected in September, when they are ripe, carefully dried by means of artificial heat, and packed into bales or sent loose into commerce. They are sometimes treated with sulphur dioxide to improve the color and to prevent change of the active principles.

DESCRIPTION.—Cone-like, flattened, oblong or ovoid, 2 to 3 cm. long, 1·5 to 2 cm. wide, about 7 mm. thick, consisting of a sharp undulate rachis and about fifty membranous bracts, the latter distinctly veined, light

green or brownish green, glandular-hairy, entire, 10 to 14 mm. long, 7 to 11 mm. broad, with acute apex and rounded base, frequently infolded on one side and inclosing a subglobular, light-brown, very glandular achene; the seed with two flat, spirally coiled cotyledons and without a reserve layer; odor aromatic; taste bitter.

CONSTITUENTS.—Volatile oil about 0·7 per cent. and containing valerol, which upon oxidation yields isovalerianic acid, giving to the drug its characteristic odor; a crystalline, bitter principle lupamaric acid; tannin about 5 per cent.; resin 10 to 15 per cent.; calcium oxalate, and ash about 10 per cent.

COLOCYNTHIS (Bitter Apple).

The fruit of *Citrullus Colocynthis* (Fam. Cucurbitaceæ), a perennial herbaceous vine indigenous to warm, dry regions of Africa and Asia, and cultivated in the northwestern provinces of India and the countries bordering the Mediterranean. The fruit is collected in autumn when ripe, and after removal of the epicarp by paring, is quickly dried in the sun or by artificial means. The commercial supplies are obtained from Turkey and Spain, the finer grade coming from Turkey. The seeds should be removed from the pulp before it is used.

DESCRIPTION.—Berry nearly globular, 6 to 7 cm. in diameter; light; externally yellowish white; internally, with three longitudinal, somewhat elliptical fissures 8 to 14 mm. wide; seeds numerous, ovoid, compressed, yellowish green, and borne on the divided parietal placentæ between the fissures; odor slight; taste bitter.

CONSTITUENTS.—A bitter, amorphous glucoside colocynthin, about 0·5 per cent.; fixed oil in pulp about 3 per cent., and in seeds about 15 per cent.; ash about 10 per cent. in pulp and about 3 per cent. in the seeds.

CASSIA FISTULA (Purging Cassia).

The ripe fruit of *Cassia Fistula* (Fam. Leguminosæ), a tree indigenous to India, and naturalized in Tropical Africa, South America and the West Indies. The principal supply of the drug used in this country comes from Tropical America.

Description. — Legume, many-celled, indehiscent cylindrical, 25 to 50 cm. long, 15 to 20 mm. in diameter; externally reddish brown, apex acute or acuminate, base rounded, sometimes with a woody pedicel about 15 mm. long and 4 mm. in diameter, smooth, shiny, transversely striate, on one side a longitudinal groove (the ventral suture), and on the other a smooth line or slight ridge (the dorsal suture); pericarp hard and woody; internally divided by transverse partitions into numerous compartments about 5 mm. long, each containing a brownish-black pulp and a single seed; seed anatropous, ovoid, compressed, about 8 mm. long, 6 mm. wide, 4 mm. thick, light brown, the raphe as a distinct line on one of the compressed sides, internally light yellow, embryo curved and imbedded in the endosperm; odor of pulp distinct, prune-like; taste sweet.

Constituents.—Sugar 50 to 60 per cent. (in the pulp).

VANILLA.

The fruit of *Vanilla planifolia* (Fam. Orchidaceæ), a perennial climber indigenous to Eastern Mexico, and now cultivated in various tropical islands, including the Seychelles, Mauritius, Java, as well as in the provinces of Vera Cruz and Oaxaca in Mexico, from whence the best fruit is derived. The fruits are gathered when mature but while still yellowish green, and slowly dried, either in the sun or by artificial means, during which process the odorous principles are developed.

Description.—Pods narrow, linear, about 20 cm. long, 7 mm. in diameter, 4 mm. thick; apex oblique, with a circular scar; base curved or bent, with a slightly enlarged circular scar; externally blackish brown, longitudinally wrinkled, moist, glossy, frequently with numerous monoclinic prisms of vanillin; pericarp about 1 mm. thick; internally dark brown, one-celled, with numerous seeds imbedded in a dark-colored liquid; seeds anatropous, ovoid, flattened, 0·2 to 0·3 mm. in diameter, black, finely reticulate, reserve layers wanting, embryo shrunken; odor and taste distinct.

Constituents.—A colorless crystalline principle, vanillin from 1·5 to 2·5 per cent.; fixed oil about 10 per cent.; calcium oxalate; ash about 5 per cent.

FICUS (Fig).

The fruit of *Ficus Carica* (Fam. Moraceæ), a tree indigenous to Persia and cultivated in most subtropical and temperate countries. The fruit is collected when ripe, partially dried in the sun, and tightly packed in boxes.

Description.—Syconium, pyriform or obovoid, usually compressed, about 6 cm. long and 1·5 cm. in diameter; externally light brown, longitudinally veined, wrinkled, frequently with an efflorescence of sugar, apex with a small scaly orifice, base with a scar or stalk about 7 mm. long and 4 mm. thick, and also with a leaf-remnant; receptacle hollow, the walls 2 to 3 mm. thick, coriaceous, tough, the inner portion with numerous lanceolate divisions, upon which are borne numerous ovoid brownish-yellow glossy achenes about 1 mm. in diameter, the latter with a reserve layer and a curved embryo; odor distinct, fruit-like; taste sweet.

Constituents.—Sugar 50 to 60 per cent.

AURANTII DULCIS CORTEX (Sweet Orange Peel).

The outer layer of the rind of the fresh fruit of *Citrus Aurantium* (Fam. Rutaceæ), a tree resembling *Citrus vulgaris*, but more widely cultivated. The outer yellowish layer is the part employed, and is usually removed from the fruit by grating. The dried rind is also an article of commerce.

DESCRIPTION.—Cut into small pieces or shreds; externally orange-yellow, with numerous circular depressions and numerous large oil-secretion reservoirs; fracture coriaceous, tough; soft when fresh; odor aromatic; taste slightly bitter.

CONSTITUENTS.—Resembling those of bitter orange peel, except that the bitter principles are not present.

LIMONIS CORTEX (Lemon Peel).

The rind of the fresh fruit of *Citrus medica*, var. *Limonum* (Fam. Rutaceæ), a tree indigenous to Northern India and cultivated in the European countries bordering the Mediterranean, the West Indies and other tropical and subtropical countries. The outer yellowish layer is the part used and it is removed by grating.

DESCRIPTION.—In freshly grated lemon-yellow fragments, with numerous large oil-secretion reservoirs and oil-globules; odor aromatic; taste aromatic and slightly bitter.

CONSTITUENTS.—Volatile oil, hesperidin, calcium oxalate, ash about 4 per cent.

URANTII AMARI CORTEX (Bitter Orange Peel).

The rind of the unripe fruit of *Citrus vulgaris* Risso (Fam. Rutaceæ), a tree indigenous to Northern India and cultivated in the Mediterranean region, the West Indies and the States bordering on the Gulf of Mexico

The fruit is collected before it is ripe, the rind removed and used either in the fresh or dried condition. The commercial article is obtained from Malta, Sicily and Spain.

Description.—Usually cut longitudinally into quarters; elliptical, acute at both ends, 4 to 6 cm. long, 2 to 3 cm. wide, 2 to 6 mm. thick; externally yellowish or brownish green, with numerous circular depressions, a scar at one end and occasionally the remains of the calyx; internally light yellowish brown, wrinkled, with numerous conical projections and numerous large oil-secretion reservoirs; fracture short, tough, porous; odor aromatic; taste aromatic and bitter.

Occasionally in ribbon-like bands 2 to 12 cm. long, 5 to 10 mm. wide, about 2 mm. thick, externally yellowish brown.

Constituents.—Volatile oil; two bitter principles aurantiamarin and aurantiamaric acid; a tasteless, crystalline glucoside hesperidin; tannin; calcium oxalate; ash about 5 per cent.

TAMARINDUS (Tamarind).

The preserved pulp of the ripe fruit of *Tamarindus Indica* (Fam. Leguminosæ), a tree indigenous to Tropical Africa and cultivated in the West and East Indies, from whence the two chief commercial varieties are obtained.

Description. — **West Indian Tamarind.** — Usually a blackish-brown mass, with a distinct odor and strongly acidulous, sweet taste, and in which are imbedded numerous seeds inclosed in a loose tough membrane; seeds anatropous, oblong or flattened-quadrangular, 12 to 14 mm. long, 8 to 11 mm. broad, 5 to 7 mm. thick, dark reddish brown, smooth, one edge furrowed, transversely striate, very hard; cotyledons plano-convex.

East Indian Tamarind.—In blackish cakes, containing less sugar and more acid.

CONSTITUENTS.—Tartaric acid 5 to 9 per cent.; citric acid 3 to 6 per cent.; potassium bitartrate about 5 per cent., and other salts of organic acids; sugar; tannin (in the seed-coats).

LUPULINUM (Lupulin).

A powder separated from Hops (see Humulus), and consisting chiefly of the glandular hairs. Lupulin may be systematically separated from the hops, or it may be obtained as a by-product during the handling of the hops. Commercial lupulin consists for the most part of sweepings collected where hops are prepared for the market, the extraneous matter being removed by sifting and washing. The powder is then carefully dried and preserved.

DESCRIPTION.—Granular, yellowish or reddish brown, consisting of secretion hairs with a somewhat globular or ellipsoidal, bright-yellow, multicellular head 0·1 to 0·3 mm. in diameter; odor aromatic; taste aromatic and bitter.

Not less than 60 per cent. of lupulin should be soluble in ether, and the ash should not be more than 10 per cent.

CONSTITUENTS.—A volatile oil, identical with that of hops, about 3 per cent.; a crystalline bitter principle lupamaric acid; resin; a volatile, liquid alkaloid choline; volatile acids, and ash from 3 to 5 per cent.

VI. LEAVES AND HERBS.

Some of the most valuable and potent vegetable drugs are those furnished by leaves and herbs. In quite a number of instances the leaves alon eare collected; not infrequently, as with herbaceous plants, the

leaves, together with the flowering and fruiting tops, are collected; rarely, however, are the tops alone employed; occasionally the drug may consist of the entire plant. It may be noted in this connection that some of the so-called leaf-drugs, as belladonna, hyoscyamus and stramonium, may contain the tops of the plants as well, and some of the commercial herbs, as lobelia, may consist entirely of leaves.

KEY FOR THE STUDY OF LEAVES AND HERBS.

I. *Leaves*.

1. Nearly entire.

A. Texture coriaceous.

a. Margin entire.

α Margin revolute.

Apex emarginate . . . . Pilocarpus
Apex obtuse . . . . Uva Ursi

β Margin not revolute.

Scythe-shaped . . . . Eucalyptus

b. Margin dentate or serrate.

Glandular-punctate . . . . Buchu
Not glandular-punctate . . . . Chimaphila

B. Texture not coriaceous.

a. Margin entire.

Not less than 15 mm. broad . . . . Coca
Not more than 15 mm. broad . . . . Senna

b. Margin not entire.

Margin sinuate . . . . Hamamelis
Margin crenulate . . . . Salvia

2. Leaves crumpled or in broken fragments.

A. Texture coriaceous.

Upper surface resinous . . . . Eriodictyon

B. Texture not coriaceous.

a. Hairy.

Surface reticulate . . . . Digitalis
Surface not reticulate . . . . Hyoscyamus

b. Not hairy.

Margin entire . . . . Belladonnæ Folia
Margin sinuate . . . . Stramonii Folia

II. *Leaves and Flowering Tops.*

1. With composite flowers.
    Leaves reticulate . . . . Eupatorium
    Leaves resinous . . . . Grindelia
2. With labiate flowers.

A. Very hairy.
    Taste bitter . . . . Marrubium

B. Not hairy.
    a. Margin slightly serrate.
        Leaves dark green, pubescent . . . . Hedeoma
    b. Margin serrate, midrib and veins somewhat rose or purple-colored.
        Taste aromatic, followed by a cooling sensation . . . . Mentha Piperita
        Taste aromatic . . . . Mentha Viridis

3. Of solanaceous origin, odor narcotic.

A. Margin entire.
    Purplish flowers, brownish berries . . Belladonnæ Folia

B. Margin not entire.
    Margin sinuate, surface hairy . . . . Hyoscyamus
    Margin four-lobed, surface not hairy . . Stramonii Folia

4. With inflated capsules.
    Leaf divisions with gland-like apex . . . . . . Lobelia

III. *Flowering Tops, leaves few.*

Compressed resinous masses . . . . . . Cannabis Indica

IV. *Stem Tops, leaves few.*

Branches with yellowish-green wings . . . . Scoparius

V. *Entire Plant.*

Stem, leaves and capsules well defined, very bitter . . . . Chirata

PILOCARPUS (Jaborandi).

The leaflets of various species of *Pilocarpus* (Fam. Rutaceæ), shrubs indigenous to Brazil. There are three principal commercial varieties: (1) Pernambuco Jaborandi, obtained from *P. Jaborandi;* (2) Paraguay Jaborandi, yielded by *P. pennatifolius*, and (3) Maranham Jaborandi, obtained from *P. microphyllus.* The name, jaborandi, is applied to a number of other plants in Brazil besides those of the genus *Pilocarpus.*

Description.—Pernambuco Jaborandi.—Elliptical, lanceolate or oblong-lanceolate, 6 to 12 cm. long, 1·5 to 4 cm. broad; apex obtuse, more or less emarginate; base rounded or acute, unequal; margin entire, slightly revolute; upper surface dark green or brownish green, glabrous, midrib more or less depressed near the apex, veins of the first order prominent, diverging at an angle of 35° to 50° and uniting with each other near the margin; under surface yellowish or greenish brown, pubescent, with numerous light-brown projections, midrib prominent, yellowish brown; petiolule 3 to 5 mm. long; pellucid-punctate; texture coriaceous, brittle; odor slight; taste bitter, somewhat aromatic, becoming pungent.

Paraguay Jaborandi.—Oblong-lanceolate, ovate or obovate, 8 to 12 cm. long, 2·5 to 5 cm. broad; apex slightly emarginate; base equal; margin very slightly revolute; upper surface dark green, midrib and veins of the first order not very prominent, the latter diverging at an angle of 25° to 45°; under surface grayish green or light green, glabrous, with numerous papillæ; midrib yellowish, with few short hairs; frequently with numerous black disks of a *Puccinia* on both surfaces; texture as in Pernambuco jaborandi, but only about one-half as thick.

Maranham Jaborandi.—Oblong-ovate, or oblanceolate, 1·5 to 4 cm. long, 1·5 to 2·5 cm broad; apex deeply emarginate; base tapering into the petiolule; margin distinctly revolute; upper surface bright green, glabrous, sometimes shiny, midrib prominent, veins of the first order not very prominent, diverging at an angle of 35° to 45°; under surface grayish green; frequently with numerous black disks of a *Puccinia* on both surfaces; petiolule about 8 mm. long; texture as in Paraguay jaborandi but thinner.

CONSTITUENTS.—Several alkaloids amounting to from 0·5 to 1 per cent., of which the most important is pilocarpine; volatile oil about 0·5 per cent., and calcium oxalate.

UVA URSI (Red Bearberry).

The leaves of *Arctostaphylos Uva-ursi* (Fam. Ericaceæ), a procumbent shrub indigenous to Europe, Asia and the Northern United States and Canada.

DESCRIPTION.—Obovate, spatulate, 18 to 30 mm. long, 6 to 10 mm. broad; apex obtuse; base acute, tapering; margin entire, slightly revolute; upper surface dark green, glabrous, finely reticulate; under surface yellowish green; petiole about 3 mm. long, slightly pubescent; texture coriaceous, brittle; odor slight; taste slightly bitter, astringent.

CONSTITUENTS.—Two glucosides—arbutin and ericolin, the former being apparently the more important medicinally, and yielding upon hydrolysis hydroquinone; a crystalline, resinous principle urson; tannin about 5 per cent.; gallic acid; ellagic acid; a yellow crystalline coloring principle; calcium oxalate; ash about 3 per cent.

EUCALYPTUS.

The leaves of *Eucalyptus Globulus* (Fam. Myrtaceæ), a tree indigenous to Eastern Australia and Tasmania, and cultivated in Southern Europe, California and the Southern United States. The leaves are collected from older parts of the tree and dried, the principal part of the commercial supply coming from the South of France.

DESCRIPTION. — Dorsiventral, lanceolate, scythe-shaped, 15 to 30 cm. long, 2·5 to 5 cm. broad; apex acuminate; base somewhat unequal, acute; margin

entire, revolute; surface light green, glabrous, with numerous small circular reddish-brown depressions or projections in the neighborhood of the stomata and veins, consisting of cork cells;[1] midrib usually with a small groove on the dorsal side; veins of the first order diverging at an angle of about 55°, running to within 1 mm. of the edge, where they anastomose, forming a vein parallel with the margin; petiole 2 to 3 cm. long, flattened and somewhat twisted; pellucid punctate; texture coriaceous; odor slightly aromatic; taste aromatic, somewhat bitter and cooling.

Constituents.—Volatile oil 3 to 6 per cent., of which over 60 per cent. is eucalyptol; several resins; a bitter principle; tannin and calcium oxalate.

BUCHU.

The leaves of several species of *Barosma* (Fam. Rutaceæ), a shrub indigenous to Cape Colony. There are two chief commercial varieties: (1) Short Buchu obtained from *B. betulina* and (2) Long Buchu, obtained from *B. serratifolia*, the short buchu being preferred.

Description.—**Short Buchu.**—Obovate, rhomboid-obovate or elliptical; 9 to 18 mm. long, 6 to 12 mm. broad; apex obtuse, somewhat recurved; base acute or cuneate; margin sharply dentate and with an oil-secretion reservoir at the base of each tooth; upper surface yellowish green, glabrous; under surface yellowish green, longitudinally striate; both surfaces papillose; petiole about 1 mm. long; texture coriaceous; odor and taste distinct, aromatic.

Long Buchu.—Linear-lanceolate, 25 to 40 mm. long, 4 to 6 mm. broad; apex somewhat rounded.

Constituents.—Short buchu contains about 1·5 per

[1] These corky patches appear to be due to an irritation caused by some of the constituents.

cent. of volatile oil, of which about 30 per cent. is diosphenol; long buchu contains only about one-third as much volatile oil and it contains little or no diosphenol; buchu also contains two crystalline glucosides, diosmin and hesperidin, mucilage and calcium oxalate.

Allied Plants.—The leaves of *Barosma crenulata* are occasionally found in the market; they are oblong-lanceolate, about twice as broad as long buchu, margin slightly toothed, apex more or less rounded, and the yield of oil is about as much as that of short buchu.

Adulterants.—The leaves of *Empleurum serrulatum* (Fam. Rutaceæ) are sometimes offered for long buchu, from which they differ in having an acute but somewhat acuminate apex, which is glandless, a peculiar odor and a bitter taste.

CHIMAPHILA (Pipsissewa).

The dried leaves of *Chimaphila umbellata* (Fam. Ericaceæ), a perrenial herb indigenous to the United States and Southern Canada and Northern Europe and Siberia.

Description.—Lanceolate or oblanceolate, 2·5 to 5 cm. long, 8 to 18 mm. broad; apex obtuse or acute; base acute or cuneate; margin sharply serrate; upper surface dark green, not mottled, glabrous, shiny; midrib and veins depressed, the latter diverging at an angle of about 60° and uniting with each other near the margin; under surface yellowish green; petiole about 1 mm. long; texture coriaceous, brittle; odor slight; taste astringent, bitter.

Constituents.—A neutral, crystalline principle chimaphilin; two glucosides—arbutin and ericolin; a crystalline, resinous principle urson; tannin about 4 per cent.; calcium oxalate; ash about 5 per cent.

COCA (Coca Leaves).

The leaves of *Erythroxylon Coca*, and its varieties (Fam. Erythroxylaceæ), shrubs probably indigenous to Bolivia and Peru, where they are extensively cultivated, as well as in Java and Ceylon. The leaves are picked two or more times a year and carefully dried in the sun. There are two principal commercial varieties—Bolivian (Huanco) and Peruvian (Truxillo), the former being preferred:

Description.—**Bolivian Coca.**—Oval, obovate or elliptical, 3 to 7 cm. long, 2 to 3 cm. broad; apex acute, slightly mucronate; base acute; margin entire, somewhat revolute; upper surface dark green, glabrous, midrib with a distinct ridge; under surface yellowish green, distinctly undulate, with numerous minute papillæ, frequently with a row of collenchymatous cells about 4 mm. on either side of the midrib and extending from the base to the apex; petiole dark brown, 1 to 6 mm. long; texture somewhat coriaceous; odor distinct; taste bitter, and producing a sensation of numbness.

Peruvian Coca.—Leaves usually more broken, 3 to 5·5 cm. long, 1·5 to 2 cm. broad; upper surface light green, ridge on the midrib faint or wanting; under surface light yellowish green, the curved line on either side of the midrib usually wanting; more or less fragile; sensation of numbness produced by it not so pronounced.

The flowers of a species of *Inga* (Fam. Leguminosæ) are frequently present. The pedicel is about 2 mm. long; the calyx yellowish brown, about 1 cm. long, five-toothed, pubescent; corolla cylindrical, or somewhat funnel-shaped, five-toothed, about 1 cm. long, yellowish brown, very pubescent; stamens numerous, more or less united into a tube, exserted, filaments reddish brown.

Constituents.—Several alkaloids, including cocaine, cinnamyl-cocaine, and truxilline; of these cocaine is the most important, the Bolivian leaves containing the greatest amount, or 0·5 to 1 per cent.; the other alkaloids preponderate in the Peruvian leaves; the Java leaves also contain benzoyl-pseudotropeine; in addition, coca leaves contain tannin and calcium oxalate.

SENNA (Senna Leaves.)

The leaflets of various species of *Cassia* (Fam. Leguminosæ), small shrubs indigenous to Upper Egypt and Southern Arabia. There are two important commercial varieties: (1) Alexandrian Senna, derived from wild plants of *Cassia acutifolia*, and exported by way of Alexandria and Red Sea ports; (2) Indian or Tinnivelly Senna, derived from cultivated plants of *Cassia angustifolia*, growing in Southern India, particularly the district of Tinnivelly. The leaves are carefully collected and dried, the Tinnivelly variety being more largely used, although the Alexandrian is more highly esteemed.

Description. — **Alexandrian Senna.** — Lanceolate or ovate-lanceolate; 1·5 to 3 cm. long, 5 to 8 mm. broad; apex acute, mucronate; base unequal, acute; margin entire; upper surface pale green, nearly glabrous, midrib sometimes depressed, veins of first order more or less prominent; under surface light grayish green, midrib prominent, minutely pubescent, especially near the veins; petiolule about 1 mm. long; texture coriaceous, fibrous; odor slight; taste somewhat bitter.

Tinnivelly Senna.—From 2·5 to 5 cm. long, upper surface light green, lower surface slightly pubescent.

Constituents.—An amorphous glucoside cathartic acid; chrysophanic acid; an emodin resembling that

of aloes; a bitter glucoside sennapicrin; an acrid glucoside rhamnetin; calcium oxalate; ash 10 to 12 per cent.

Allied Plants.—The leaves of *Cassia Marilandica* (wild or American senna), a perennial herb indigenous to the Eastern and Central United States and Canada, contain principles closely resembling those of Alexandrian and Indian senna, these leaves having been official in the U.S.P up to 1880.

Senna pods are also found in the market, either admixed with the leaves or sold separately; they are from 35 to 70 mm. long and about 20 mm. broad, greenish to dark brown externally, and contain from five to seven obovate, dark brown, nearly smooth seeds. They contain apparently the same active principles as the leaves.

HAMAMELIS (Witch-Hazel Leaves).

The leaves of *Hamamelis Virginiana* (Fam. Hamamelidaceæ), a shrub indigenous to the Eastern United States and Canada. The leaves are collected in autumn, and are used in the fresh condition, or dried; when dried they should be carefully preserved and not kept longer than one year.

Description. — Broadly elliptical, or rhomboid-obovate, more or less unequal; 3·5 to 12 cm. long, 2·5 to 7 cm. broad; apex rounded, acute or acuminate; base obliquely cordate; margin sinuate or sinuate-dentate; upper surface dark green, veins of the first order diverging at an angle of about 60° and running nearly parallel to the margin, with grayish patches of a mold and slightly pubescent; under surface light green, pubescent, midrib and veins prominent; petiole 5 to 12 mm. long; texture coarse, brittle; odor slight; taste astringent.

Constituents.—Volatile oil; a bitter principle; tannin; gallic acid, and calcium oxalate.

Allied Products.—The bark of *Hamamelis Virginiana* is also considerably used; it is collected in spring and occurs in market in transversely curved pieces of varying length and about 1 mm. thick; externally smooth, grayish or dark brown, more or less fissured and scaly; inner surface pinkish and longitudinally striate; fracture of the outer part short, of the inner part fibrous; odor slight; taste astringent, bitter. The constituents appear to be similar to those of the leaves.

SALVIA (Sage).

The leaves of *Salvia officinalis* (Fam. Labiatæ), a perennial herb indigenous to Southern Europe, and cultivated in England, France, Germany and the United States. The leaves are collected when the plants are in flower, and carefully dried in the shade.

Description.—Oblong-lanceolate, 2 to 10 cm. long, 1 to 2·5 cm. broad; apex acute; base rounded or somewhat heart-shaped; margin crenulate; upper surface grayish green, densely pubescent, midrib and veins depressed; under surface light grayish green, midrib prominent, veins of first order diverging at an angle of 55° and running nearly parallel to the margin, minutely reticulate and densely pubescent; petiole 1 to 4 cm. long, upper side grooved, grayish purple; texture velvety, more or less pliable; odor aromatic; taste aromatic and bitter.

Constituents. — Volatile oil about 0·5 per cent.; resin and tannin.

ERIODICTYON (Yerba Santa).

The dried leaves of *Eriodictyon Californicum* (Syn. *E. glutinosum*) (Fam. Hydrophyllaceæ), an evergreen

shrub indigenous to the mountains of California and Northern Mexico.

Description.—Usually broken into fragments; lamina lanceolate, 7 to 15 cm. long, 1 to 3 cm. broad; apex acute; base acute, slightly tapering into the petiole; margin nearly entire or unevenly serrate; upper surface yellowish green, glabrous, resinous; under surface grayish green, reticulate, minutely tomentose between the reticulations, midrib light yellow, prominent; petiole 5 to 10 mm. long; texture coriaceous, brittle; odor and taste balsamic.

Constituents.—A volatile oil; resin about 25 per cent.; eriodictyonic acid about 2 per cent.; a glucoside ericolin; tannin and calcium oxalate.

DIGITALIS (Fox Glove).

The leaves of *Digitalis purpurea* (Fam. Scrophulariaceæ), a biennial herb probably indigenous to Central and Southern Europe, and cultivated and naturalized in various parts of Europe and the United States and Canada. The leaves are collected in June from plants of the second year's growth, just before the commencement of flowering, immediately dried and carefully preserved. Germany furnishes the chief supply, the leaves from both cultivated and wild plants being used.

Description.—Usually more or less crumpled and broken into fragments; lamina ovate-oblong or ovate-lanceolate, 10 to 25 cm. long, 5 to 15 cm. broad; apex obtuse or rounded; base somewhat cuneate, tapering into the petiole; margin dentate or crenate, the divisions with a yellowish-brown gland-like apex; upper surface dark green, minutely hairy, somewhat wrinkled, with a single water-pore near the apex of each tooth; under surface grayish green, midrib grayish brown,

prominent, from which veins of the first order diverge at angles of 45° to 65° and unite with one another near the margin, and from which arise other anastomosing nerves giving a distinctly reticulate appearance; distinctly pubescent on the veins and frequently on the reticulations; petiole about one-third the length of the lamina or in the upper leaves nearly wanting, grayish brown, laminated, texture fragile; odor distinct; taste bitter.

Leaves that are more than 30 cm. long should be rejected, as also the tuft of radical leaves of the first-year plant.

Constituents.—Several crystalline glucosides, including digitoxin (0·2 to 0·3 per cent.), digitalin and digitonin, the former two being the more important. The digitalins on the market are of varying composition, containing in addition to true digitalin, digitoxin and digitonin, other principles of digitalis. The drug also contains a yellow, crystalline coloring principle, resin, and ash about 10 per cent.

HYOSCYAMUS (Henbane).

The leaves and flowering tops of *Hyoscyamus niger* (Fam. Solanaceæ), an annual or biennial herb probably indigenous to Europe and Western Asia, and cultivated in Germany, Russia, England and the Northern United States and Canada, and also naturalized in waste places. Hyoscyamus is collected shortly after flowering from biennial plants of the second year's growth, and carefully dried and preserved. The commercial article comes chiefly from Germany.

Description.—Usually in irregular matted fragments. Stem hollow, cylindrical, flattened, longitudinally furrowed and wrinkled, 3 to 4 mm. in diameter;

internodes 1 to 3·5 cm. long. Leaves ovate or ovate-lanceolate, 5 to 10 cm. long, 2 to 7 cm. broad, apex acuminate; base amplexicaul; margin acutely four-lobed; upper surface dark green and pubescent; under surface grayish green and glandular-pubescent; midrib yellowish green, from which veins of the first order diverge at an angle of from 10° to 35° and pass into the lobes; texture fragile. Flowers solitary and with a pedicel about 4 mm. long; calyx tubular, five-toothed, about 10 mm. long, outer surface very pubescent; corolla five-parted, the lobes more or less unequal, somewhat spreading, the tube purplish, the limb yellowish, reticulate from purplish veins; stamens, five, declined, mostly exserted; stigma capitate. Fruit, a two-celled pyxis. Seeds numerous, campylotropous, somewhat reniform, flattened, 1 mm. long, light brown, finely pitted, with a curved embryo imbedded in the endosperm. Odor distinct. Taste bitter and somewhat acrid.

Constituents.—Hyoscyamus contains several alkaloids identical with those of belladonna leaves, and in addition, scopolamine (or hyoscine); there is also present potassium nitrate about 2 per cent. and calcium oxalate.

BELLADONNÆ FOLIA (Belladonna Leaves).

The leaves and flowering tops of *Atropa Belladonna* (Fam. Solanaceæ), a perennial herb native of Central and Southern Europe, and cultivated in England and Germany, from which countries most of the commercial supply is obtained. The leaves and tops are gathered when the plants are in flower, and used either fresh or after being dried.

Description.—Usually in irregular matted fragments. Stem hollow, cylindrical, flattened, longitudi-

nally furrowed and wrinkled, 1·5 to 2 mm. in diameter, internodes from 2·5 to 6·5 cm. long. Leaves single or in unequal pairs, broadly ovate or somewhat elliptical, 6 to 15 cm. long, 2·5 to 7 cm. broad; apex acuminate; base acute, somewhat unequal and tapering into the petiole; margin entire; upper surface dark green, glabrous, epidermis with distinct papillæ; under surface grayish green, slightly pubescent on the veins, epidermis distinctly sinuate, midrib dark brown, the veins of the first order diverging from it at angles of about 45° and running nearly parallel to near the margin; petiole dark brown, 5 to 15 mm. long and semi-circular in cross section; texture fragile. Flowers solitary, pedicel 1·5 to 2 cm. long; calyx deeply five-cleft, about 1 mm. long, outer surface slightly pubescent; corolla five-parted, about 2 mm. long, campanulate, yellowish purple; stamens five, distant, included; style somewhat exserted. Fruit, a superior berry, globular, dark green, 7 to 10 mm. in diameter, two-celled, many-seeded. Seeds campylotropous, somewhat reniform, flattened, light brown; testa finely pitted; with a curved embryo imbedded in the endosperm. Odor distinct, heavy. Taste somewhat disagreeable.

Constituents.—Several alkaloids amounting to from 0·3 to 0·7 per cent., of which hyoscyamine exists in largest proportion; the drug also contains atropine, formed from hyoscyamine, as well as other alkaloids; malic acid and calcium oxalate.

STRAMONII FOLIA (Stramonium Leaves).

The leaves and flowering tops of *Datura Stramonium* (Fam. Solanaceæ), an annual herb probably indigenous to the region of the Caspian Sea, naturalized in waste places in Europe and North America, and cultivated

in France, Germany and Hungary. The leaves and tops are collected when the plant is in flower, and are carefully dried and preserved, the chief of the commercial supply being obtained from cultivated plants.

Description.—Usually in irregular matted fragments. Stem cylindrical, flattened, longitudinally furrowed and wrinkled, 2 to 5 mm. in diameter; internodes 1·5 to 2 cm. long. Leaves ovate, 6 to 20 cm. long, 2 to 12 cm. broad; apex acuminate; base unequal, one side extending 3 to 12 mm. below the other; margin irregularly sinuate-lobed, the lobes acute; upper surface dark green, nearly glabrous, under surface yellowish green, glabrous, slightly pubescent on the veins, midrib dark brown, veins of the first order diverging from it at an angle of 45° to 65°, dividing near the margin and the main branch passing into the lobes; petiole dark brown, 0·5 to 4·5 cm. long, circular in cross section; texture fragile. Flowers solitary, pedicel 2 to 10 mm. long, calyx five-toothed, about 4 cm. long, separating transversely near the base at maturity, the upper part falling away; corolla funnel-shaped, yellowish or purplish white, about 8 cm. long, limb plaited, five-lobed; stamens five, included, inserted near the middle of the corolla tube; stigma slightly two-lobed. The immature fruit somewhat conical, four-valved. Seeds numerous. Odor disagreeable. Taste unpleasant, nauseous.

Constituents.—The important constituents of Stramonium leaves are similar to those of belladonna leaves, the amount of total alkaloids, however, being about one-half less.

EUPATORIUM (Boneset).

The leaves and flowering tops of *Eupatorium perfoliatum* (Fam. Compositæ), a perennial herb indigenous

to Eastern and Central North America. Boneset is collected in July and August and dried.

DESCRIPTION.—Usually in more or lesss broken fragments. Stem cylindrical, somewhat quadrangular, flattened, about 3 mm. in diameter, longitudinally wrinkled, tomentose; internodes 5 to 8 cm. long. Leaf lanceolate, opposite, 10 to 20 cm. long, 2 to 4 cm. broad; apex acuminate; base connate-perfoliate; margin crenate-serrate; upper surface dark green, midrib and veins depressed, reticulate, glabrous, except near the margin; under surface yellowish or brownish green, midrib prominent, reticulate, very tomentose, with glistening yellow resin masses. Flowers in large terminal corymbs; heads ten to fifteen-flowered, about 5 mm. long, receptacle flat; involucre light green, oblong, the scales imbricate, linear-lanceolate, hairy; corolla five-toothed, whitish; anthers purplish, included; style deeply cleft, much exserted. Achenes five-angled; pappus smooth, consisting of a single row of about twenty rough bristles. Odor aromatic. Taste bitter.

CONSTITUENTS.—Volatile oil; a bitter, crystalline glucoside eupatorin; resin; a crystalline wax; tannin; gallic acid; ash about 8 per cent.

GRINDELIA.

The leaves and flowering tops of *Grindelia robusta* and *Grindelia squarrosa* (Fam. Compositæ), perennial herbs indigenous to Western North America, *G. robusta* growing west of the Rocky Mountains and *G. squarrosa* eastward therefrom as far as the Mississippi. Grindelia is collected in early summer when the leaves and tops are covered with a resinous exudation, and dried.

DESCRIPTION.—**Grindelia Robusta.**—Stem cylindrical, lemon-yellow or rose-colored, 2 to 3 mm. in diameter,

longitudinally wrinkled, glandular-hairy, nearly glabrous, resinous; internodes 8 to 35 mm. long. Leaf lanceolate or oblanceolate; apex acute; base sessile or amplexicaul; margin entire or spinosely toothed; upper surface light green or yellowish green, covered with resin and with occasional black disks of *Puccinia;* under surface grayish green, somewhat resinous; texture somewhat coriaceous, brittle when dry. Heads many-flowered, globular or truncate-conical, about 1 to 2 cm. in diameter, with numerous lanceolate-acuminate, imbricate and resinous involucral bracts; receptacle flat, deeply pitted; ray-flowers brownish yellow and pistillate; tubular flowers yellowish brown, perfect. Achenes slightly curved, somewhat compressed, about 3 mm. long, the base tapering, apex one to four-toothed. Odor aromatic. Taste aromatic and bitter.

Grindelia Squarrosa.—Heads with spreading involucral bracts.

Constituents.—An acrid resin; volatile oil; two glucosides, somewhat resembling the saponins in quillaja and senega; an alkaloid; tannin; ash about 8 per cent.

MARRUBIUM (White Horehound).

The leaves and flowering tops of *Marrubium vulgare* (Fam. Labiatæ), a perennial herb indigenous to Europe and Asia, and cultivated in various parts of Europe and the United States, being naturalized in waste places from Texas and Mexico to Maine and Ontario. Marrubium is collected when the plant is in flower and dried.

Description. — Stem quadrangular, yellowish or grayish green, 3 to 5 mm. in diameter, very pubescent; internodes 2 to 5 cm. long. Leaves broadly

ovate, opposite, 1·5 to 6 cm. long, 8 to 25 mm. broad; apex obtuse; base acute or rounded; margin coarsely crenate; upper surface dark green, pubescent, veins depressed, those of the first order diverging at an angle of about 65° and branching near the margin; under surface grayish green, very pubescent, veins prominent; petiole 0·5 to 3 cm. long, very pubescent. Flowers sessile, in axillary clusters; calyx tubular, about 5 mm. long, five to ten-nerved, very pubescent and with ten recurved bristle-like lobes; corolla whitish or light brown, about 7 mm. long, upper lip erect, entire or bifid, lower lip three-lobed, the middle lobe the largest and emarginate; stamens four, included. Nutlets brownish black, ellipsoidal, slightly compressed, about 1·5 mm. long, nearly smooth. Odor slight, aromatic. Taste aromatic and bitter.

CONSTITUENTS.—Volatile oil; a bitter crystalline principle marrubiin; resin and tannin.

HEDEOMA (American Pennyroyal).

The leaves and flowering tops of *Hedeoma pulegioides* (Fam. Labiatæ), an annual herb indigenous to the Eastern and Central United States and Canada. Pennyroyal should be collected in July or August and dried.

DESCRIPTION.—Stem quadrangular, 1 to 2 mm. in diameter, light or reddish brown, with numerous spreading hairs. Leaves elliptical or ovate, opposite, 15 to 35 mm. long, 5 to 14 mm. broad; apex obtuse; base tapering into the petiole; margin remotely serrate; upper surface dark green, pubescent on the nerves, slightly glandular-hairy; under surface light green, pubescent, glandular-hairy, veins of the first order diverging at an angle of 45° to 65°, curving upwards and uniting near the margin; petiole 3 to 6 mm. long,

with numerous spreading hairs and slightly laminate in the upper portion. Inflorescence in six-flowered axillary whorls; calyx tubular, about 5 mm. long, ovoid or slightly curved on the lower side near the base, bilabiate, upper lip three-toothed, lower lip with two linear-lanceolate divisions, thirteen-nerved, longitudinally striate, pubescent; corolla about the size of the calyx, purplish, pubescent, upper lip erect, flat, emarginate, the lower spreading and three-lobed; fertile stamens two, exserted, ascending, the sterile upper pair rarely with anthers. Nutlets nearly spherical, about 0·5 mm. in diameter. Odor strongly aromatic. Taste aromatic.

Constituents.—Volatile oil about 1 per cent.; a bitter principle and tannin.

Allied Plants.—*Mentha Pulegium*, or European pennyroyal, apparently contains principles similar to the American pennyroyal, and is distinguished from the latter by the more or less oval serrate leaves, and the cymose inflorescence with four-lobed corolla.

MENTHA PIPERITA (Peppermint).

The leaves and flowering tops of *Mentha piperita* (Fam. Labiatæ), a perennial herb indigenous to Europe, naturalized in the Eastern and Central United States and Canada, and cultivated in Michigan and New York. Peppermint should be collected during dry weather, in August and September, when the plant is in flower, and carefully dried and preserved.

Description.—Stem quadrangular, 1 to 3 mm. in diameter, yellowish green, with scattered deflexed hairs, internodes 1·5 to 5 cm. long. Leaves ovate-lanceolate, opposite, 1·5 to 8 cm long, 0·5 to 2·5 cm. broad; apex acute; base acute or rounded; margin sharply serrate; upper surface dark green, midrib and veins rose-col-

ored, the latter diverging at an angle of about 60°, curving upward and uniting near the margin; under surface light green, slightly pubescent on the veins, glandular-pubescent; petiole 4 to 10 mm. long, slightly pubescent. Inflorescence in axillary whorls or in interrupted spikes; peduncle wanting or about 3 mm. long, pedicel about 1 mm. long; calyx tubular, equally five-toothed, about 2 mm. long, purplish, glandular-punctate; corolla tubular, nearly regular, four-cleft, about 3 mm. long, purplish; stamens four, erect, distant. Nutlets ellipsoidal, about 0·5 mm. in diameter, blackish brown. Odor aromatic. Taste aromatic, followed by a cooling sensation.

Constituents.—Volatile oil, containing about 50 per cent. of menthol, about 1 per cent.; resin and tannin.

Allied Plants.—A number of other species of *Mentha* contain principles similar to those of *M. piperita;* of these may be mentioned *M. arvensis* var. *piperascens,* yielding the Japanese peppermint and *M. Canadensis* var. *glabrata,* yielding the Chinese peppermint, the oils from these plants being rich in menthol.

MENTHA VIRIDIS (Spearmint).

The leaves and flowering tops of *Mentha spicata* (Syn. *Mentha viridis*) (Fam. Labiatæ), a perennial herb indigenous to Europe and cultivated and naturalized in various parts of North America. It should be collected in the same manner as peppermint.

Description.—Closely resembling peppermint (see Mentha Piperita), but the stems are usually more purple, the leaves usually sessile, inflorescence either in slender interrupted cylindrical spikes or crowded lanceolate spikes, and the taste is not followed by a cooling sensation.

Constituents.—Volatile oil about 0·5 per cent., con-

taining from 35 to 55 per cent. of carvone (the oil from the Russian spearmint containing about 50 per cent. of linalool and 5 to 10 per cent. of carvone); resin and tannin.

LOBELIA.

The leaves and flowering tops of *Lobelia inflata* (Fam. Campanulaceæ), an annual herb indigenous to the Eastern and Central United States and Canada, and cultivated in New York and Massachusetts. Lobelia should be collected after a portion of the capsules have become inflated, carefully dried and preserved.

Description.—Stem cylindrical, somewhat angular, slightly winged, light brown, with numerous spreading hairs, internodes 2 to 3 cm. long. Leaves elliptical or ovate-lanceolate, alternate, 4 to 9 cm. long, 8 to 30 mm. broad; apex acute or acuminate; base obtuse or acute; margin irregularly denticulate, the divisions with a yellowish-brown gland-like apex; upper surface yellowish green or light brown and with scattered bristly hairs; under surface light brown, with numerous bristly hairs, the veins of the first order diverging at an angle of about 65° and curving upward near the margin; petiole either wanting or about 1 mm. long. Inflorescence in leafy spikes; pedicel about 3 mm. long; calyx five-parted, about 5 mm. long, the subulate lobes about as long as the tube; corolla five-parted, tubular, about as long as the calyx, pale blue, upper portion cleft nearly to the base, the lobes on either side of the cleft erect or recurved, the other three united; stamens with anthers united above into a curved tube; stigma two-lobed, ovary two-celled. Fruit an ovoid inflated capsule 5 to 8 mm. long, opening at the summit, apex with the remains of the calyx. Seeds numerous, brownish, somewhat ellipsoidal or ovoid, about 0·7

mm. long, coarsely reticulate. Odor slight. Taste mild, becoming acrid.

Constituents.—An amorphous, acrid, emetic alkaloid lobeline, which decomposes readily on heating, and is contained in greatest amount in the seeds; a non-acrid but pungent volatile oil lobelianin; a crystalline neutral principle inflatin, and lobelic acid. The seeds contain in addition a fixed oil which, when obtained by pressure, is said to contain all the active principles of the drug.

CANNABIS INDICA (East Indian Hemp).

The flowering tops of the pistillate plants of *Cannabis sativa* (Fam. Moraceæ), an annual herb indigenous to Central and Western Asia, and cultivated in nearly all temperate regions for the fiber and seed. The drug, however, is obtained from plants cultivated in Tropical India. The flowering tops are made into more or less compressed masses, forming what is known as "ganja" or "guaza." The best grade of ganja is obtained from unfertilized plants grown in Bengal. The leaves may be collected and dried separately and constitute what is known as "bhang." The resin which separates from ganja and bhang, or which is collected from the growing plant, constitutes what is known as "charas." *Cannabis sativa* has become naturalized in the Central United States, and while the American drug was at one time official, is now but little used in medicine. Fruiting spikes with mature seeds should be removed.

Description.—Usually in compressed masses 5 to 14 cm. long. Stem cylindrical, about 3 mm. in diameter, longitudinally furrowed and wrinkled, light green, pubescent, internodes 2 to 20 mm. long. Leaf digitately compound, with three to seven linear-lanceolate nearly sessile leaflets, apex of leaflets acuminate, base

acute or cuneate, margin deeply serrate; upper and under surfaces dark green, pubescent, glandular, veins of the first order diverging at an angle of 65° and terminating in the teeth; petiole 1 to 5 cm. long. Inflorescence in sessile spikes, each flower subtended by an ovate, pubescent bract; calyx entire, ovate or oblong-acuminate, about 4 mm. long, dark green, pubescent, split longitudinally on one side, somewhat enlarged at the base and folded around the ovary; styles two, about 8 mm. long, filiform, pubescent, ovary oblong, about 1 mm. long, with a single campylotropous ovule. Odor distinct. Taste slightly acrid.

Constituents.—Resin from 15 to 20 per cent., consisting of a number of principles, one of which, cannabinol, is said to possess the physiological properties of the drug; the latter also contains a volatile oil, potassium nitrate and calcium oxalate.

SCOPARIUS (Broom).

The tops of *Cytisus Scoparius* (Fam. Leguminosæ), a shrub indigenous to the temperate parts of Europe, and naturalized in waste places from Virginia to Nova Scotia. The tops are gathered before flowering and are used in the fresh condition, or they are dried.

Description.—Usually cut branches; the latter alternate, pentangular, 2 to 3 mm. thick; externally dark green, with five yellowish-green wings and numerous reddish-brown cork patches, the younger branches somewhat pubescent; fracture short, fibrous or of pieces thick, tough, splintery; internally yellowish, bark thin, wood slightly porous, pith large, about 1 mm. in diameter. Leaves elliptical, obovate, simple above, 5 to 10 mm. long, 3 to 4 mm. broad, digitately trifoliate below; apex of both leaves and leaflets acute; base acute; margin entire; upper surface

dark green, nearly glabrous; under surface slightly pubescent; petiole wanting in the simple leaves and about 5 mm. long in the compound leaves, pubescent. Odor peculiar. Taste bitter.

Constituents.—A volatile liquid alkaloid sparteine, forming crystalline salts, the sulphate of which has physiological properties similar to digitalin; a crystalline principle scoparin; volatile oil; tannin; ash about 5 per cent.

CHIRATA.

The entire plant of *Swertia Chirata* (Fam. Gentianaceæ), an annual herb indigenous to the mountains of Northern India. The plants are collected after the capsules are fully formed, dried and made into bundles.

Description.—Usually in flat bundles tied with a strip of bamboo and about 1 M. long, 15 cm. wide and 7 cm. thick. Root simple, tapering, about 7 mm. thick near the crown; externally yellowish brown, wrinkled, with few rootlets; internally, bark whitish, about 2 mm. thick, wood yellow, porous, radiate. Stem cylindrical, flattened, quadrangular above, each angle with a decurrent wing, about 1 M. long, 4 to 6 mm. thick, yellowish or purplish brown, longitudinally wrinkled, internodes 3 to 8 cm. long; internally, bark yellowish brown, very thin, easily separable, wood yellowish, slightly porous, radiate, 0·5 to 1 mm. thick, pith lemon-yellow, 2 to 3 mm. in diameter, easily separable from the wood, sometimes wanting. Leaves opposite, ovate-lanceolate, about 6 cm. long, 2·5 cm. in diameter; apex acuminate; base somewhat amplexicaul; margin entire; upper and under surfaces brownish green, midrib prominent and with three to seven parallel lateral veins. Inflorescence a large panicle; flowers numerous, regular; calyx about 4 mm. long and

with four lanceolate divisions; corolla yellow, rotate, about 10 mm. long, with 4 lanceolate lobes, each with a pair of nectaries above the base; stamens four, inserted at the base of the corolla tube; style slender, with two recurved stigmas; ovary one-celled, with two parietal placentæ. Fruit a superior, ovoid, pointed, yellowish brown, bicàrpellary, unilocular capsule. Seeds numerous, anatropous, somewhat oblong, flattened, about 0·5 mm. long, testa reticulate; embryo small, straight, imimbedded in the endosperm. Odor slight. Taste extremely bitter.

Constituents.—Two amorphous, bitter principles: one a glucoside chiratin, which is precipitated by tannin, the other non-glucosidal and not precipitated by tannin. The drug also contains resin, tannin and ash 4 to 8 per cent.

Allied Plants.—Other species of *Swertia*, as well as other bitter plants known in India as "chiretta," find their way into the market. These are, however, easily distinguished from the true drug.

VII. EXUDATIONS, JUICES AND OTHER PLANT PRODUCTS.

A large number of substances are used in medicine which represent to a greater or less extent the constituents of the cells or alteration or decomposition products of them. These are in the nature of exudations, inspissated juices, extracts, products of distillation, etc. The exudation products of milk-vessels or secretion-reservoirs are eliminated either through natural or artificial wounds of the stem, and they are collected in special receptacles, as in the case of gamboge, scammony and turpentine; or they are allowed to dry and more or less harden on the stem, afterward being collected, as acacia and tragacanth; or the more or less

plastic or partially dried exudation may be made into masses, as those of lactucarium and opium. These products may be grouped according to their origin as follows:

1. Natural Exudations.

Carbohydrates	Gummy exudations		Acacia
			Tragacantha
	Saccharine exudation		Manna
Non-carbohydrates	Balsam		Styrax
	Balsamic resin		Benzoin
	Oleo-resins		Terebinthina
			Terebinthina canadensis
	Gum resins		Asafetida
			Cambogia
			Myrrha
			Scammonium
	Resins		Guaiaci resina
			Mastiche
			Pix burgundica
	Milk juices		Elastica
			Lactucarium
			Opium

2. An Excrescence.

The product of the puncture of an insect . . . . Galla

3. Artificial Products.

Carbohydrates—Starch grains		Amylum
Non-carbohydrates	Extract	Catechu
	Inspissated juices	Aloe
		Kino

Products of destructive distillation . . . . Pix Liquida
Residue from the distillation of turpentine . . . . Colophony

For convenience in study, as well as identification, the drugs of this class may also be grouped as follows:

I. *Solid.*
  1. In powder form.
     White, inodorous, nearly tasteless . . . . Amylum
  2. Not in powder.
     A. More or less spherical in form.
        a. In tears.
           Whitish or yellowish white, mucilaginous . Acacia
           Pale yellowish or greenish yellow, resinous, Mastiche
        b. Not in tears.
           Somewhat spherical . . . . Galla
     B. In cylindrical pieces.
        Grayish orange-brown . . . . Cambogia
        Blackish brown (see seeds) . . . . Guarana

C. In cubes.
Dull reddish brown . . . . Gambir

D. In quadrangular pieces, one side convex.
Dull reddish or grayish brown, odor opium-like . . . . Lactucarium

E. In three-sided elongated pieces.
Yellowish white, odor of maple sugar . . . . Manna

F. In bands.
Whitish or pale yellowish, mucilaginous . Tragacantha

G. In angular fragments.
Whitish, inodorous and nearly tasteless . . Amylum
Amber-colored, odor terebinthinate . . . Colophony
Small dark reddish-brown, brittle, astringent pieces . . . . Kino
Greenish gray or brownish black, odor peculiar . . . . Scammonium

H. In rounded masses.
Grayish brown, odor distinct, heavy . . . . . Opium

I. In irregular masses.
Orange-brown to blackish brown, odor distinct, taste bitter . . . . Aloes
Dull reddish brown, astringent . . . . Catechu
Brownish black, elastic . . . . Elastica
Greenish brown, odor balsamic . . . Guaiaci Resina
Reddish brown or yellowish brown, odor terebinthinate . . . . Pix Burgundica

J. In irregular masses composed of matrix and tears.
Whitish tears, matrix yellowish brown or brownish gray, odor alliaceous . . . . . Asafetida
Yellowish brown tears, matrix reddish brown, odor balsamic . . . . Benzoinum

K. In masses composed of tears.
Brownish red or yellowish brown, balsamic . Myrrha
Yellowish, terebinthinate . . . . Terebinthina

II. *Liquid or Semi-Liquid.*

Blackish brown, empyreumatic and terebinthinate . . . . Pix Liquida
Grayish, balsamic . . . . Styrax
Pale yellowish, transparent, terebinthinate Terebinthina Canadensis

AMYLUM (Starch).

The starch grains obtained from the fruits of wheat, corn and rice. The grains are separated from the cells, purified in various ways, and subsequently washed with large quantities of water. In the U. S. Pharmacopœia cornstarch alone is recognized.

DESCRIPTION.—**Corn Starch.**—In fine powder or irregular angular, white, inodorous, tasteless masses; grains somewhat spherical, but usually polygonal, with a lenticular, circular or triangular point of origin of growth, about 10 to 25 μ in diameter.

Wheat Starch.—Usually in a fine powder consisting of nearly spherical or ellipsoidal grains with point of origin of growth and lamellæ more or less indistinct, about 15 to 40 μ in diameter.

Rice Starch.—Usually in a grayish-white powder consisting of minute angular grains about 5 to 8 μ in diameter and with point of origin of growth and lamellæ indistinct.

Starch is insoluble in cold water or alcohol, but forms a white jelly when boiled with water, which, when cool, gives a deep-blue color with iodine and should give a neutral reaction to litmus paper (commercial cornstarch is usually alkaline); ash not more than 1 per cent.

ACACIA (Gum Arabic).

A dried gummy exudation from the stem and branches of *Acacia Senegal* and probably other species of *Acacia* (Fam. Leguminosæ), trees indigenous to Northern Africa. The gum arises as a decomposition product of the walls of some of the cells of the bark, and exudes spontaneously, or the trees are incised, which increases the production of gum. The more or less hardened pieces are collected and then sorted into different grades, the market supplies being obtained

from Egypt by way of Alexandria, from the Soudan by way of Suakin, and from Senegambia by way of the port of St. Louis.

DESCRIPTION.—In roundish tears of variable size, or broken into angular fragments; externally whitish or yellowish white; translucent; very brittle, with a glass-like, sometimes iridescent fracture; nearly inodorous; taste mucilaginous.

Acacia is not soluble in alcohol, but is completely soluble in water; the solution gives an acid reaction with litmus paper, yields a gelatinous precipitate with basic lead acetate solution (Ghatti gum giving but a slight precipitate), ferric chloride or concentrated solution of sodium borate, and does not give a bluish or reddish color with iodine (absence of starch or dextrin), or a brownish-black precipitate with ferric chloride (absence of Mesquite gum), and does not reduce Fehling's solution (absence of gums containing sugars).

The powder contains few or no altered or unaltered starch grains or vegetable tissues.

CONSTITUENTS.—A crystalline glucoside, which is apparently Arabic acid in combination with calcium, magnesium and potassium, and which constitutes the greater part of the gum; ash 3 to 4 per cent.

ADULTERANTS.—Various species of Acacia indigenous to Tropical Africa and Australia, as well as *Anogeissus latifolia* (Fam. Combretaceæ) (the latter being the source of the so-called Ghatti gum), yield gums which, while resembling true acacia, do not respond to the tests given above.

The powder, while sometimes adulterated with dextrin and rice starch, is more frequently mixed with inferior gums, especially the Mesquite gum, which is yielded by *Prosopis glandulosa*, a tree indigenous from Mexico to Colorado.

MASTICHE (Mastic).

The dried resinous exudation from *Pistacia Lentiscus* (Fam. Anacardiaceæ), a large shrub indigenous to the Mediterranean region. The resin exudes through incisions made in the bark, and when dry is collected. The chief source of supply is the island of Scio.

DESCRIPTION.—Somewhat globular or ovoid tears 3 to 7 mm. long, pale yellow or greenish yellow, translucent, having a glass-like luster, sometimes covered with a whitish dust; brittle; fracture conchoidal, becoming plastic when chewed; odor slight, balsamic; taste mild, terebinthinate.

Mastic is completely soluble in ether and almost completely soluble in alcohol; the acid number should not be less than 65.

CONSTITUENTS.—Resin about 90 per cent.; volatile oil 2 to 3 per cent.

ALLIED PLANTS.—Various other species of *Pistacia* found in India and Northern Africa yield resins resembling mastic.

GALLA (Nutgall).

An abnormal development on the young twigs of *Quercus infectoria* (Fam. Cupuliferæ), caused by the deposited ova of a Hymenopterous insect, *Cynips tinctoria.* Nutgalls are collected before the maturing of the insect, and are obtained principally from Aleppo, in Asiatic Turkey.

DESCRIPTION.—Aleppo Galls.—Somewhat spherical, 1 to 2 cm. in diameter; externally grayish brown or dark grayish green, more or less tuberculate above, the basal portion nearly smooth, and contracted into a short stalk, sometimes with a perforation on one side; heavy; fracture horny; internally yellowish or dark brown, consisting of a central portion which con-

tains starch, and occasionally the partly developed insect, and an outer zone which is porous, lustrous and occasionally traversed by a radial canal; odor slight; taste strongly astringent.

Constituents.—The principal constituent is tannin, which is found to the extent of 50 to 70 per cent.; the drug also contains gallic acid 2 to 4 per cent., starch and resin.

Allied Products.—Chinese and Japanese galls are produced on *Rhus semialata* by a species of *Aphis*, and are chiefly used in the manufacture of tannic and gallic acids. They are irregular, somewhat ovoid, more or less tuberculate, grayish brown, very hairy, light in weight, brittle, the wall about 1 mm. thick, and the cavity containing the remains of numerous insects.

CAMBOGIA (Gamboge).

A gum-resin obtained from *Garcinia Hanburii* (Fam. Guttiferæ), a tree indigenous to Siam, Cochin China and Cambodia. Spiral incisions are made in the bark of the trees, and the gum-resin which exudes is collected in hollow bamboo stems; it is then allowed to dry slowly, after which the bamboo is removed. It is chiefly exported by way of Singapore.

Description.—In cylindrical pieces, frequently hollow in the center, of variable length, 2 to 5 cm. in diameter; externally grayish orange-brown, longitudinally striate; hard; fracture short, orange-red, waxy and somewhat porous; inodorous; taste very acrid.

The powder is bright yellow, sternutatory, and contains few or no starch grains; not more than 25 per cent. should be insoluble in alcohol.

Constituents.—Gum about 20 per cent.; a resin known as cambogic acid about 75 per cent.; ash 1 to 3 per cent.

ADULTERANTS.—Gamboge is sometimes adulterated with vegetable fragments, inorganic substances, as sand, etc., and wheat or rice flour, which it may contain to the extent of nearly 50 per cent.

LACTUCARIUM.

The dried milk-juice of *Lactuca virosa* and other species of *Lactuca* (Fam. Compositæ), biennial herbs indigenous to Central and Southern Europe and cultivated in France, England and Germany, certain species being more or less naturalized in the United States. Lactucarium is obtained by cutting off the tops of the stems; and when the latex which exudes is partially hardened, it is collected and dried in hemispherical earthen cups until it can be cut into pieces, usually four in number, these being further dried.

DESCRIPTION.—In irregular angular pieces or quadrangular sections, one surface of which is convex; externally dull reddish or grayish brown; fracture tough, waxy; internally light brown or yellowish, somewhat porous; odor distinct, opium-like; taste bitter.

Lactucarium is partly soluble in alcohol and in ether, and should not give a reaction for starch.

CONSTITUENTS.—Three bitter principles: lactucin, lactucopicrin and lactucic acid, the latter being crystalline; also a colorless, odorless and tasteless crystalline principle lactucerin; volatile oil; mannit; organic acids, as citric, malic and oxalic, and ash 7 to 10 per cent.

MANNA.

The dried saccharine exudation from the stems of *Fraxinus Ornus* (Fam. Oleaceæ), a small tree indigenous to Southern Europe, where it is also cultivated, particularly in Sicily. Manna is obtained by making transverse or oblique incisions in the bark, the exudation

flowing down the side of the tree where it hardens, or it is collected in special receptacles.

DESCRIPTION.—In irregular, three-sided, more or less elongated pieces, one side being smooth and concave; externally yellowish white; friable, somewhat waxy; internally whitish, porous and crystalline; odor suggestive of maple sugar; taste sweet, slightly bitter and acrid.

CONSTITUENTS.—The principal constituent is mannit (80 to 90 per cent.). Manna also contains a green fluorescent principle fraxin; dextrose as high as 16 per cent.; mucilage; resin, and a small amount of inorganic substances.

ALLIED PRODUCTS.—The term "manna" is applied to a number of exudations obtained from different sources and of varying composition, none of which, however, appear to be supplied as a substitute for true manna, although they might be employed in a similar manner.

Manna of inferior quality, known as "sorts," is obtained from incisions lower down on the stem, and consists of brownish yellow, more or less agglutinated tears, which are sticky and but slightly crystalline.

TRAGACANTHA (Tragacanth).

A gummy exudation from the stem of *Astragalus gmmiferu* and other species of *Astragalus* (Fam. Leguminosæ), shrubs indigenous to Western Asia. Tragacanth exudes naturally, or it is obtained by making transverse incisions in the stem, the gum being collected after it dries. The principal points of export are Smyrna and various ports along the Persian Gulf; that obtained from the latter is known as Persian or Syrian Tragacanth and is preferred.

DESCRIPTION. — Persian or Syrian Tragacanth. — In flattened, lamellated, ribbon-like pieces, varying in length and from 1 to 3 mm. thick, irregularly oblong, more or less curved; externally nearly colorless or pale yellowish; translucent; fracture short, tough, horny, rendered more easily purverizable by a heat of 50° C.

CONSTITUENTS.—Traganthin (bassorin), 60 to 70 per cent.; a carbohydrate apparently in the nature of an insoluble compound of arabic (gummic) acid, which swells in water but is insoluble in it; arabin about 10 per cent., soluble in water and probably formed from traganthin; starch; ash about 3 per cent.

ALLIED PRODUCTS.—Smyrna tragacanth, which is collected in Asiatic Turkey and shipped from Smyrna, occurs in pieces that are less ribbon-like, more opaque, and contain considerably more starch than the Syrian or Persian varieties.

COLOPHONY (Rosin or Resin).

The residue left after the distillation of the crude oleo-resin (or turpentine) of *Pinus palustris* and other species of *Pinus* (Fam. Pinaceæ), evergreen trees indigenous to the Southern United States.

DESCRIPTION.—Usually in sharp angular fragments; translucent, amber-colored, usually covered with a yellowish dust, hard, brittle, pulverizable, fracture shiny and shallow-concoidal; odor and taste faintly terebinthinate.

Resin has a specific gravity of 1·070 to 1·080, and it is soluble in alcohol, ether, benzol, carbon disulphide, acetic acid, fixed and volatile oils and in solutions of potassium or sodium hydrate; the acid number should not be less than 150.

CONSTITUENTS.—From 80 to 90 per cent. of an anhydride of abietic acid, which on treatment with alcohol

is changed into abietic acid, which latter is crystalline; other acids are also present, as pinic and sylvic; ash about 1 per cent.

Resin is not infrequently used as an adulterant of other resinous products, as of Burgundy pitch and Venice turpentine.

KINO.

The inspissated juice of *Pterocarpus Marsupium*, and probably other species of *Pterocarpus* (Fam. Leguminosæ), trees indigenous to Southern India and Ceylon. The juice is obtained from incisions made in the bark, and allowed to dry in the sun. The drug is exported from Madras and is known as Malabar or East Indian Kino. Kino is also obtained from *Eucalyptus rostrata* and other species of *Eucalyptus* (Fam. Myrtaceæ), trees indigenous to New South Wales, this product being known as Australian Kino, Red Gum or Eucalyptus Gum.

Description.—**Malabar or East Indian Kino.**—Small, angular, opaque, ruby-red, translucent, glistening, brittle pieces; inodorous; sweetish, very astringent and adhering to the teeth when chewed.

Kino is entirely soluble in alcohol; only partially soluble in cold water; not less than 80 per cent. should be soluble in boiling water.

Australian Kino.—In masses or small fragments; dark reddish brown; somewhat dusty and tough.

Constituents.—Tannin about 50 per cent; kino red, and 2–6 per cent. of ash. Malabar kino contains in addition kinoin, a colorless crystalline principle apparently derived from the tannin.

Allied Products.—The term kino is applied to various astringent plant juices which, while they contain large amounts of tannin, do not appear to be as valuable as either the Malabar or Australian kino.

SCAMMONIUM (Scammony).

A gum resin obtained by incising the root of *Convolvulus Scammonia* (Fam. Convolvulaceæ), a perennial, twining herb indigenous to Syria, Asia Minor and Greece. The incisions are made in the upper part of the root and the exuding gum-resin is collected in mussel shells, after which it is allowed to dry. The principal points of export are Smyrna and Aleppo.

Description.—In circular cakes or irregular angular pieces of variable size; greenish gray or brownish black, often covered with a grayish-white powder; very brittle; fracture sharp; internally porous, lustrous and of a uniform brownish-black color, being more or less translucent in thin fragments; odor peculiar, somewhat cheese-like; taste slightly acrid.

Scammony does not effervesce on the addition of diluted hydrochloric acid (absence of calcium carbonate); an alcoholic solution is not colored blue on the addition of tincture of ferric chloride (absence of guaiac resin); ether dissolves not less than 70 per cent. (distinction from jalap resin), and when the residue left on evaporation of the ethereal solution is dissolved in hot solution of potassium hydrate it is not reprecipitated on the addition of diluted sulphuric acid.

Constituents.—From 75 to 90 per cent. of resin, which is completely soluble in ether; gum 5 to 8 per cent.; ash not more than 3 per cent.

Adulterants.—Scammony is adulterated with inorganic substances, various starchy products, foreign resins, such as guaiac, and an extract of the juice of the root.

OPIUM.

The dried milk-juice of the capsules of *Papaver somniferum* (Fam. Papaveraceæ), an annual herb probably

indigenous to Asia, and now cultivated in Asia Minor, China, India, Persia and Turkey (European). Experiments have been made both in this country and Europe to cultivate the opium poppy, but so far these experiments have been unprofitable. Opium is obtained by making transverse, oblique or longitudinal incisions in the unripe capsule; the latex which exudes is collected when partly dried and made into a mass. The latter is inclosed in a covering of rumex or poppy leaves and further dried, subsequently being packed in bags with rumex berries to prevent the masses from sticking together. While there are a number of varieties of opium, that used in this country is principally from Turkey and is exported chiefly from Smyrna and Constantinople.

Description.—**Turkey Opium.**—In irregular, flattened, more or less rounded masses of variable size and weighing from 250 to 1,000 grammes; externally grayish brown, covered with remnants of poppy leaves and with occasional fruits of a species of *Rumex;* internally dark brown, granular, somewhat lustrous, more or less plastic when fresh, but becoming hard and darker on keeping; odor distinct, heavy; taste peculiar, bitter.

Constituents.—A large number of alkaloids have been obtained from opium and its extracts, some of which are no doubt alteration products of the alkaloids naturally occurring in the drug; the most important of these is morphine, which exists to the extent of 5 to 22 per cent., the largest amount being obtained from Turkey opium, the Persian ranking next, and the smallest amount being obtained from Indian opium. Narcotine is found to the extent of 2 to 10 per cent., and is contained in larger proportion in Persian and Indian opium than in the Turkey variety. Among other alkaloids may be mentioned codeine, 0·5–2·0 per

cent., and narceine. Opium also contains about 5 per cent. of meconic acid, which gives with ferric chloride a deep-red color, and the yield of ash is 4 to 8 per cent.

Allied Products.—**Persian Opium.**—Usually in more or less conical masses weighing about 350 grammes, and usually wrapped in paper; externally dark brown; internally more or less homogeneous.

Indian Opium.—In flat cakes weighing about 200 grammes or rounded masses weighing about 2 kilogrammes wrapped in oiled paper. This variety is sent chiefly to China.

Adulterants.—Opium sometimes contains fragments of the capsules, the pulp of figs and other fruits, tragacanth, starch, and various inorganic substances, as clay, sand, etc. While starch is not usually admixed with Turkey opium it is nearly always present in the Persian variety.

ALOE (Aloes).

The inspissated juice of the leaves of various species of *Aloe* (Fam. Liliaceæ), perennial succulents indigenous to Africa and India and naturalized in the West Indies. There are three principal commercial varieties of aloes: (1) Socotrine Aloes, derived from *Aloe Perryi*, and probably other species of *Aloe*, growing on the island of Socotra and in Eastern Africa, and exported by way of Bombay; (2) Curaçao Aloes obtained from *Aloe Chinensis* and *Aloe vera* growing in Curaçao and other islands of the Dutch West Indies; and (3) Cape Aloes, obtained from a certain species of *Aloe* growing in Southern Africa, and exported from Cape Town and Mossel Bay. The leaves of the Aloe plant are cut transversely and the juice which exudes is allowed to evaporate spontaneously, it being usually, however, concentrated by boiling and then poured into

boxes or gourds, and occasionally it is found in commerce inclosed in monkey skins. Socotrine aloes commands the highest price.

Description.—**Curacao Aloes.**—In orange to blackish-brown opaque masses, translucent in thin pieces; fracture uneven, waxy, somewhat resinous, occasionally exhibiting microscopical crystals of aloin; odor distinct, unpleasant; taste nauseous, bitter. The powder is dark brown and gives an immediate deep reddish color with cold nitric acid or with solutions of the alkalies.

Socotrine Aloes.—In yellowish-brown to dark-brown opaque masses, or smooth and glassy, fracture somewhat conchoidal; odor saffron-like; powder yellowish brown or brownish yellow, giving a yellowish or reddish-brown color with nitric acid.

Cape Aloes.—Of a reddish-brown or of an olive-black color, transparent in thin pieces; fracture smooth and glassy; powder greenish yellow, becoming light brown and greenish with nitric acid.

Constituents.—A crystalline, bitter principle aloin, the percentage (4·5 to 25 per cent.) and composition of which vary in the different varieties, the Curaçao aloin being distinguished from Socotrine and Cape aloin by giving a reddish color with cold nitric acid; the drug also contains resin, emodin, volatile oil, and yields about 1 per cent. of ash.

Adulterants.—Aloes is likely to contain various mechanical impurities, hence the necessity for a purified aloes. The aloin is sometimes removed, as in the Curaçao aloes, which may then be sold for Cape aloes.

CATECHU.

An extract prepared from the heartwood of *Acacia Catechu* (Fam. Leguminosæ), a tree indigenous to

India and Burmah, and from the leaves and twigs of *Uncaria* (*Ourouparia*) *Gambir* (Fam. Rubiaceæ), a climbing shrub indigenous to the Malay Archipelago, and also cultivated in many of the islands thereof, the former being known as "black catechu" or "cutch," and the latter as "pale catechu," "gambir" or "terra japonica." These extracts are prepared by boiling the parts of the trees and shrubs yielding them with water, evaporating the strained liquid to a syrupy consistence and allowing it to harden.

DESCRIPTION.—**Black Catechu.**—In irregular masses, with fragments of leaves or mats upon the outside, dark brown, somewhat shiny; brittle, more or less porous internally; odor slight; taste astringent and sweetish.

Catechu is somewhat soluble in cold water, the undissolved portion containing acicular crystals; almost entirely soluble in boiling water, the solution giving an acid reaction; not less than 70 per cent. should be soluble in 90 per cent. alcohol. Few or no starch grains or vegetable tissues should be present.

Pale Catechu.—Usually in more or less porous irregular cubes, about 25 mm. in diameter; externally dull reddish brown; friable; internally paler, consisting chiefly of microscopical crystals; odor slight; taste bitter and very astringent.

CONSTITUENTS.—Catechutannic acid 25 (black catechu) to 35 per cent. (pale catechu); catechin; catechu-red, quercetin, and ash about 3 per cent. Pale catechu contains in addition a fluorescent principle.

ADULTERANTS.—Catechu is sometimes adulterated with other plant extracts, with various inorganic substances, and starch. On account of the inferior quality of black catechu in recent years the pale catechu has superseded it.

ELASTICA (Caoutchouc, India-Rubber).

The milk-juice of *Hevea Braziliensis*, and probably other species of *Hevea* (Fam. Euphorbiaceæ), trees indigenous to Brazil. The milk-juice is obtained by making incisions in the bark of the tree; it is then allowed to coagulate and dry. The best grade is known as Para Rubber. Rubber is also obtained from a number of other plants, as various members of the Urticaceæ and Apocynaceæ.

Description.—In elastic flask-shaped masses or pieces of varying form and size; light, floating in water; externally brownish to brownish black; internally brownish, mottled; odor slight; nearly tasteless.

Caoutchouc is insoluble in water, dilute acids, or dilute solutions of the alkalies; more or less soluble in chloroform, carbon disulphide, oil of turpentine, benzin and benzol.

Constituents.—Caoutchouc consists chiefly of two hydrocarbons, one of which is ductile and readily soluble in chloroform, and the other elastic and less soluble in chloroform; it is also contains 1 to 2 per cent. of resin, volatile oil, etc.

GUAIACI RESINA (Guaiac Resin).

A resin obtained from the stem and branches of *Guaiacum officinale* and *Guaiacum sanctum* (Fam. Zygophyllaceæ), evergreen trees indigenous to the West Indies and the northern part of South America. The resin exudes spontaneously or is obtained from incisions in the bark or by heating the fallen trunks. The commercial article comes chiefly from Cuba and Hayti.

Description.—Usually in irregular masses; externally greenish brown, frequently covered with a greenish powder; brittle, the fracture having a glassy luster and being yellowish green or reddish brown and more

or less transparent in thin pieces; fusible; odor balsamic; taste somewhat acrid.

Not more than 15 per cent. of guaiac resin is insoluble in alcohol, and the alcoholic solution turns blue on the addition of tincture of ferric chloride; the acid number is not less than 70, indicating the absence of colophony.

Constituents.—Several acids are present, including guaiaconic, about 70 per cent., guaiaretic and guaiacic, the first giving a blue color with nitric acid and other oxidizing agents; among the other constituents are resin, gum and guaiac yellow; the yield of ash should not be more than 4 per cent.

PIX BURGUNDICA (Burgundy Pitch).

The resinous exudation of the stems of *Picea excelsa* (Fam. Pinaceæ), an evergreen tree indigenous to Europe and Northern Asia. The resin is obtained by making incisions through the bark into the wood, the resin exuding and solidifying; it is then collected, and purified by melting it in hot water and straining. The chief sources of supply are Finland, the Black Forest (Germany) and the Jura Mountains.

Description.—Irregular, hard, opaque or translucent pieces, more or less plastic and adhesive, yellowish brown or reddish brown, brittle, the fracture shiny, conchoidal; odor agreeably terebinthinate; taste aromatic and sweetish.

Burgundy Pitch is partly soluble in cold alcohol (1:20), and almost entirely soluble in boiling alcohol or in glacial acetic acid.

Constituents.—Chiefly resin, together with a little volatile oil.

Adulterants.—Burgundy pitch is sometimes substituted by various mixtures, as of other coniferous

products and palm oil; these are distinguished by being more or less opaque and somewhat porous and not having the characteristic odor of the genuine article, and also by the formation of a turbid mixture on the addition of two parts by weight of glacial acetic acid.

ASAFETIDA.

A gum-resin obtained from the root of *Ferula fœtida* and other species of *Ferula* (Fam. Umbelliferæ), perennial herbs indigenous to Eastern Persia and Western Afghanistan. Asafetida is obtained by incising the crown of the root when the gum-resin exudes, hardens and is then scraped from the root; it is exported by way of Bombay.

Description.—In irregular masses composed of tears of variable size and a yellowish-brown or brownish-gray matrix; when fresh the tears are tough, yellowish white and translucent or milky white and opaque, changing gradually to pinkish and finally reddish brown, and becoming, by drying, hard and brittle; odor persistent, alliaceous; taste bitter, alliaceous and acrid.

Asafetida yields a milk-white emulsion when triturated with water, which becomes yellowish on the addition of solutions of the alkalies. Treated with strong hydrochloric acid, the filtrate gives a blue fluorescence on making it alkaline with ammonia water, distinguishing it from ammoniac. The freshly fractured surface gives a greenish color on the application of a few drops of 40 per cent. nitric-acid solution, distinguishing it from galbanum. Not less than 40 to 50 per cent. should dissolve in alcohol.

Constituents.—Resin about 60 per cent.; gum about 25 per cent.; volatile oil about 6 per cent.; ferulic acid about 1 per cent.; ash 5 to 10 per cent.

ADULTERANTS.—Asafetida frequently contains fragments of vegetable tissues, red clay, sand and stones; it is sometimes adulterated with dirty white, gritty masses of gypsum, at other times with barley or wheat flour or translucent gums.

BENZOINUM (Benzoin).

A balsamic resin obtained from *Styrax Benzoin*, and probably other species of *Styrax* (Fam. Styraceæ), trees idigenous to Java, Sumatra and Siam. The resin flows from incisions made in the bark, hardens, and is then collected, the commercial varieties being known as Siam and Sumatra Benzoin, the former being preferred.

DESCRIPTION.—**Sumatra Benzoin.**—In irregular masses composed of yellowish or reddish-brown tears of variable size and a reddish-brown and translucent or grayish-brown and opaque matrix; brittle, the tears internally being milky white; becoming soft on warming, and yielding benzoic acid on sublimation; odor agreeable, balsamic; taste slightly aromatic.

Siam Benzoin also occurs in concavo-convex tears; it has a vanilla-like odor and is almost completely soluble in solutions of the alkalies or in alcohol; it is further distinguished from the Sumatra variety in not containing cinnamic acid, and therefore does not yield benzaldehyde on boiling an acidulated solution with potassium permanganate.

Not more than 10 per cent. of Benzoin should be insoluble in alcohol, the solution giving an acid reaction.

CONSTITUENTS.—Benzoic acid partly free and partly combined with two alcohols—benzoresinol and resinotannol; vanillin; ash 1·5 to 4 per cent.

Siam benzoin contains in addition about 35 per cent.

of benzoic acid and an aromatic oily liquid, apparently an ester of benzoic acid.

Sumatra benzoin contains in addition but about 20 per cent. of benzoic acid and nearly as much cinnamic acid, and also benzaldehyde, styrol, styracin, etc., giving the drug the odor of styrax.

Allied Products.—Penang and Palembang benzoins are obtained from Sumatra and Java, respectively, and somewhat resemble the Sumatra benzoin, but they apparently do not contain cinnamic acid and yield benzoic acid, in the preparation of which they are principally employed.

MYRRHA (Myrrh).

The dried gum-resin from the stem of *Commiphora Myrrha*, and probably other species of *Commiphora* (Fam. Burseraceæ), a large shrub indigenous to Northeastern Africa (chiefly Somali Land) and Southern Arabia. The gum-resin exudes spontaneously or from incisions made in the bark; it is first of a yellowish color but soon hardens, becoming darker, and is then collected. There are two principal commercial varieties of Myrrh, the one known as African or Somali Myrrh, and the other as Arabian or Yemen Myrrh, the former being considered the better.

Description.—In irregular agglutinated tears or masses of variable size; externally rough and uneven, yellowish or reddish brown, covered with a yellowish powder; brittle, the fractured surface waxy, granular, oily, slightly mottled, somewhat translucent in thin pieces; odor balsamic; taste aromatic, bitter and acrid.

Myrrh forms a brownish-yellow emulsion when triturated with water (distinction from other gum-resins); an ethereal solution treated with bromine vapor becomes purplish (distinction from East Indian

myrrh); when moistened with nitric acid it becomes purplish (distinction from false myrrh or bdellium); not more than 70 per cent. is insoluble in alcohol.

Constituents.—Volatile oil 2·5 to 8 per cent.; resin 25 to 40 per cent.; gum about 60 per cent.; a bitter principle; ash 5 to 10 per cent.

Adulterants.—Myrrh is frequently admixed with gums and other gum resins. Of these may be mentioned several kinds of Bdellium which are obtained from various species of *Commiphora*, and which are characterized by not giving a purplish color with nitric acid. Some of these are: African bdellium, which occurs in yellowish-brown masses, that are reddish in transmitted light and have a pepper-like odor; Indian bdellium, occurring in irregular reddish-brown masses covered with minute spicules of resin, and having a terebinthinate odor and an acrid taste; and "opaque bdellium," which occurs in yellowish hard opaque masses, with a faint odor and bitter taste.

Bisabol, or East Indian myrrh, is exported from Eastern Africa and Asia; it closely resembles true myrrh, but is distinguished from it by the ethereal solution not becoming purplish with bromine vapor.

TEREBINTHINA (Turpentine).

An oleoresin obtained from *Pinus palustris* and other species of *Pinus* (Fam. Pinaceæ), evergreen trees indigenous to the Southern United States. The oleoresin is secreted in the sapwood and is obtained by making triangular incisions in the bark and wood in the spring; it flows into cavities (or boxes) made lower down on the trunk, from which it is dipped into barrels or other receptacles.

Description.—In yellowish opaque masses, brittle in the cold; lighter internally, sticky and more or less

shiny; oder and taste terebinthinate. One part dissolved in 5 parts of alcohol gives a clear solution having an acid reaction.

Constituents.—Turpentine consists of resin 70 to 80 per cent. and volatile oil 15 to 30 per cent; it also contains a bitter principle and various organic acids, as pinic, sylvic, etc.

Allied Plants.—Various other species of *Pinus* yield an oleoresin resembling turpentine, as *Pinus Tæda*, a tree growing in the regions where *Pinus palustris* is found; the yield of oleoresin from this tree is less profitable however. *Pinus sylvestris*, or Scotch fir, which is indigenous to the mountains of Europe and Asia and extensively cultivated in this country, is the source of much of the turpentine used in Europe.

Bordeaux turpentine is a product resembling American turpentine, and is obtained from *Pinus maritima* and other species of *Pinus* growing in Southern France, the resin consisting chiefly, however, of the anhydride of pimaric acid.

PIX LIQUIDA (Tar).

A product obtained by the destructive distillation of the wood of *Pinus palustris* and other species of *Pinus* (Fam. Pinaceæ), evergreen trees indigenous to the Southern United States, particularly near the Atlantic Coast and the Gulf of Mexico. Tar is obtained by distillation of the wood without access of air, the tarry liquid being collected from below.

Description.—Semi-fluid, viscid, blackish brown, non-crystalline, transparent in thin layers, becoming granular or crystalline and opaque with age; odor peculiar, aromatic, taste pungent. Tar is soluble in alcohol, fixed or volatile oils, and solution of potassium or sodium hydrate; it is heavier than water and

slightly soluble in it, the solution being of a pale yellowish-brown color, has an acid reaction, yields with a dilute solution of ferric chloride, a reddish color, and with the test-solution, an olive-green color, due to the presence of pyrocatechin, this distinguishing it from Juniper Tar, and is colored brownish red by an equal volume of calcium hydrate test-solution.

CONSTITUENTS.—Creosote about 25 per cent.; various phenols, organic acids, pyrocatechin and other aromatic compounds.

STYRAX (Storax).

A balsam obtained from the trunk of *Liquidambar orientalis* (Fam. Hamamelidaceæ), a tree indigenous to Asia Minor and the Levant. The balsam is a pathological product and is produced by wounding the bark of the tree; the bark is then removed, and from the inner part the balsam is obtained by expression with boiling water.

DESCRIPTION.—A viscid, grayish, more or less opaque semi-liquid, depositing on standing a heavier, dark-brown oleo-resinous stratum; translucent in thin layers; odor agreeable; taste balsamic.

Storax is insoluble in water; between 60 and 70 per cent. is soluble in warm alcohol, and the residue left on evaporation of the alcoholic solution is almost completely soluble in ether, carbon disulphide, or benzol, but insoluble in benzin; the portion undissolved in warm alcohol after thorough extraction with boiling alcohol should not leave more than 4 per cent. undissolved. When boiled with a solution of potassium bichromate and sulphuric acid it evolves an odor resembling that of bitter almonds (due to presence of cinnamic acid); it forms little or no foam when mixed with an equal volume of alcohol and shaken with

ammonia water, indicating the absence of turpentine and fixed oils.

CONSTITUENTS.—Storax consists chiefly of a resin-alcohol storesinol (storesin), of which there are several modifications, existing free and in combination with cinnamic acid; a fragrant volatile oil, 0·5 to 1 per cent., containing styrol (styrene, phenyl-ethylene) a hydrocarbon having the pungent taste of the drug; cinnamic acid 10 to 20 per cent.; benzoic acid; vanillin; styracin (cinnamyl cinnamate), a colorless, odorless, tasteless, crystalline principle, and also a number of other principles.

ALLIED PLANTS.—*Liquidambar Styraciflua*, a tree indigenous to the Eastern and Southern United States, yields the American storax, which occurs as a yellowish-brown semi-liquid and contains principles which appear to be somewhat similar to those of the Levant storax.

TEREBINTHINA CANADENSIS

(Canada Turpentine, Canada Balsam or Balsam of Fir).

A liquid oleoresin obtained from *Abies balsamea* (Fam. Pinaceæ), a slender evergreen tree indigenous to the Northern United States and Canada. The oleoresin occurs normally in reservoirs in the bark and forms in vesicles or blisters on the surface, from which it is obtained by puncturing them with the spout of a can used by the balsam collectors. Canada Turpentine is collected chiefly in Quebec.

DESCRIPTION.—Viscid, pale yellow or greenish yellow, occasionally with a greenish fluorescence; transparent; odor agreeable, terebinthinate; taste bitter, slightly acrid.

When exposed to the air Canada Turpentine gradually dries, forming a transparent varnish; it solidifies on mixing 5 or 6 parts with 1 part of magnesia

previously moistened with water (distinguishing it from other coniferous resins); it is completely soluble in ether, chloroform, benzol or oil of turpentine, and about 80 per cent. is soluble in alcohol (distinguishing it from other coniferous resins).

Constituents.—Resin about 75 per cent., consisting chiefly of an acid resin, and an indifferent resin canadoresene; volatile oil 20 to 25 per cent., and pimaric acid.

Allied Plants.—*Pinus Larix*, a tree indigenous to France and the Tyrol, yields the "Larch or Venice turpentine," a yellowish, slightly turbid, viscid liquid, with a terebinthinate odor, bitter and aromatic taste, which hardens very slowly when mixed with magnesia. The article imported as Venice turpentine is usually a mixture of other coniferous products.

C. DRUGS DERIVED FROM CRYPTOGAMS.

Besides the phanerogams, or those plants which produce true seeds, there is a large group of plants which are known as Cryptogams; they are also known as spore plants because they multiply by means of spores instead of seeds. The spores are distinguished from the true seeds in that they are unicellular, do not contain an embryo and are so small that the individual spores can only be studied by the use of the microscope.

Cryptogams may be divided into two principal groups: (1) Thallophyta, or stemless plants, which include the Algæ, Fungi and Lichens; (2) The Cormophyta, or "stem plants," including the Moss-like and Fern-like plants.

The Thallophyta are said to represent the lowest order of plants. They consist of a leaf-like body termed a thallus, but have no fibrovascular bundles and have

no differentiation of root, stem and leaves. In the simplest form the thallus consists of a single cell, but in the higher forms there is generally more or less differentiation in the cells.

I. ALGÆ.

In a general way the Algæ are distinguished as fresh-water algæ and salt-water algæ. They are also divided according to their color, there being green algæ, blue-green algæ, brown algæ and red algæ. In the last three the color of the chloroplastid is more or less masked or modified by the presence of coloring substances which serve to distinguish these groups.

The outer morphology of the algæ appears to be rather simple. They may consist of a single row of cells placed end to end, forming thread-like masses, as in *Lyngbya* (called mermaid hair), or cord-like masses, as in *Chorda.* In some cases the thread-like filaments may branch, as in *Griffithsia.* The same may be said of some of the algæ which are made up of a large number of cells placed side by side, as *Ceramium* and *Dasya.* In some cases the thallus is flattened, as in *Chondrus, Laminaria* and *Rhodymenia.* In other cases the cells of the plant are differentiated to such an extent that parts are developed that look like root, "hold fast;" stem, "stipe;" and leaf, "blade," as in *Laminaria.* In still other cases incrustations of calcium carbonate are produced, as in *Melobesia* and *Corallina.*

Reproduction in the algæ may be either sexual or non-sexual. Of the former, three distinct kinds are distinguished, viz.: (1) The conjugation of two cells that look essentially alike; (2) the conjugation of two cells that may be distinguished one from the other, and to which the terms male and female are

and (3) that known as "triple conjugation," as found in *Chondrus*, *Gigartina* and other red algæ.

CHONDRUS (Irish Moss, Carragheen).

The entire plant of *Chondrus crispus* (Fam. Gigartinaceæ), an alga found along the northwestern coast of Ireland, and the coast of Massachusetts. The plants are collected chiefly during June and July, spread out on the beach and bleached by the action of the sun and dew, then treated with salt water, finally dried and stored. The chief points of collection in this country are south of Boston.

Description.—Consisting of a number of dichotomously branching, somewhat enlarged segments, becoming emarginate or two-lobed, which arise from a slender, somewhat flattened base about one-half the length of the entire thallus; yellowish white, translucent, sometimes with fruit-bodies or cystocarps imbedded near the apex of the segments; somewhat cartilaginous; having a slight saline odor and a mucilaginous, somewhat saline taste.

One part of Chondrus boiled for ten minutes with 30 parts of water yields a solution which gelatinizes on cooling, and is not colored blue by iodine test-solution.

Constituents.—The principal constituent is carrageenin, a mucilaginous principle which is but slightly adhesive and differs from the true gums in not being precipitable by alcohol in aqueous solution; the drug also contains proteids, about 10 per cent.; ash 10 to 15 per cent., containing among other salts some iodides and bromides.

II. FUNGI.

The Fungi include a large number of plants which do not possess chloroplastids; therefore, they do not produce starch but may contain considerable amounts

of fixed oils. They depend for their sustenance on either living organisms, when they are known as **parasites**; or on dead organisms, when they are known as **saprophytes**. Fungi are characterized by the production of long, cylindrical, thread-like, more or less branching cells which together constitute the vegetative part of the plant, this being known as the **mycelium** or **hypha**; in some of the lower orders the mycelia have no transverse walls and are, therefore, unicellular; in other fungi the mycelia become more or less united and interwoven forming felt-like masses; in still other cases the mycelia produce in addition numerous transverse walls forming a kind of parenchymatous tissue, to which the name "pseudo-parenchyma" has been applied, as in the tube-like mycelium or "sclerotium" of ergot.

In the majority of the fungi reproduction is asexual, two distinct modes being recognized: one in which the spores arise in a mother-cell or sporangium, as in the common mold *Mucor;* and another in which the spores arise directly from the mycelium or on special hyphæ, as in *Penicillium.*

The fungi include the mildews and blights which attack the foliage and other parts of flowering plants; the water-molds which attack various aquatic animals; mushrooms and puff-balls; the smuts and yeasts, the latter of which are unicellular but do not produce a mycelium.

The fungi employed in medicine include corn smut (*Ustilago Maydis*), which grows upon various parts of Indian corn; and ergot, which replaces the grain of rye and other grasses.

ERGOTA (Ergot. Ergot of Rye).

The sclerotium of *Claviceps purpurea* (Fam. Hypocreaceæ), a fungus having two distinct periods in its

life history—an active and a resting stage. During the latter it forms a compact mycelium, or sclerotium, which replaces the flowers and grains of rye. Ergot is picked by hand from the ears of rye, or it is separated after the thrashing of the rye; it is carefully dried, and preserved against the attacks of insects by the use of small quantities of chloroform. It deteriorates with age and is not considered so valuable after one year. Russia, Spain and Germany furnish the chief part of the commercial supply, the Russian being considered the most active.

Description.—Subcylindrical, tapering toward but obtuse at both ends, somewhat curved, 2 to 4 cm. long and about 3 mm. thick; externally purplish black, longitudinally furrowed, occasionally transversely fissured, one end with the whitish remains of the sphacelia; fracture short, whitish or pinkish white, sections somewhat triangular or two-lobed; odor peculiar, heavy, increased by trituration with potassium or sodium hydrate solution; taste oily and disagreeable.

Constituents.—The constituents of ergot have been the subject of considerable investigation, and the results have been more or less contradictory. It appears to contain an alkaloid ergotinine 0·1 to 0·25 per cent.; two organic acids, ergotinic and sphacelinic; fixed oil about 30 per cent.; tannin and ash about 3 per cent. The alkaloid cornutine, which has been isolated from the extract, appears to be a decomposition product of ergotinine.

Allied Plants.—Ergot is also found on other cereals, as wheat, barley and rice, but the drug from this source is apparently not much used.

Ustilago Maydis, the fungus found upon the stem and flowers of *Zea Mays*, was formerly official as Ustilago (corn smut); it occurs in irregular, somewhat cylindri-

cal or globose masses from 10 to 15 cm. in diameter, consisting of a whitish membrane becoming dark with age, and a brownish-black mass of spores which are nearly spherical and about 7 μ in diameter. Ustilago should be carefully dried and not kept longer than one year. It contains an alkaloid, secaline; sclerotic acid; fixed oil about 3 per cent.; and other substances as well.

III. LICHENS.

The Lichens include a group of plants, the individuals of which are composed of a fungus and an alga, which have a symbiotic relationship; that is, one of mutual benefit. The fungus absorbs inorganic materials from the substratum, and the alga manufactures the organic materials from carbon dioxide and water, the two plants thus being able to live on rocks and barren places where they could not otherwise live alone.

The structure of the lichen embodies that of both the fungus and alga. The fungus consists of numerous branched hyphæ, with transverse walls, forming a well-differentiated outer and middle layer; and from that portion attached to the substratum, rhizoid-like filaments are developed. The Algæ, which are associated with Fungi in this manner, belong to the simpler forms, consisting of a single cell or chain of cells, and may be situated either in distinct portions of the hypha, as between the middle and outer layers, or scattered throughout the tissues of the fungi.

The organs of fructification are those of the fungi, chiefly of the Ascomycetes, and occur on the thallus in the lichens as more or less circular, usually dark-colored spots; these constitute the ascocarps or apothecia and are characteristic for a number of medicinal barks, as rhamnus purshiana and granatum.

A number of distinct types of lichens are recognized, depending upon the form of the thallus and how it is attached to the substratum, as crustaceous, foliaceous, fruticose, etc.

They occur on trees and rocks, but are never found on decaying organic matter. A large number form products useful to mankind. Several furnish food materials, as the reindeer moss and manna lichen, and several furnish valuable coloring principles, as litmus and orseille. Iceland moss is also used as a medicine.

CETRARIA (Iceland Moss).

The entire plant of *Cetraria islandica*, one of the Ascolichenes and widely distributed over the northern part of both continents. The chief commercial supplies are obtained from Scandinavia, Germany, Switzerland and parts of Austria.

Description.—Consisting of a number of somewhat dichotomously branching, more or less curled, papery, fringed segments, 5 to 10 cm. long and about 5 mm. wide; upper surface greenish brown, with occasional dark reddish-brown cupular apothecia; under surface grayish, with numerous small whitish depressed spots; tough when damp, but brittle when dry; odor slight; taste mucilaginous and bitter.

Constituents.—The principal constituents are lichenin and isolichenin (about 70 per cent.); the former appears to be intermediate between starch and cellulose, and is soluble in hot water, the solution becoming gelatinous on cooling but is not colored blue with iodine; isolichenin (dextrolichenin) somewhat resembles soluble starch, being soluble in cold water and giving a blue reaction with iodine; the drug also contains a bitter crystalline principle cetraric acid, about 2 per cent.; a tasteless crystalline principle, lichenos-

tearic acid, 1 per cent.; several organic acids, as oxalic and fumaric; cellulose, about 15 per cent.; and sugar.

IV. MOSS-LIKE PLANTS.

The moss-like plants or Musci include the liverworts and mosses, and are distinguished from the preceding groups in that the higher forms possess stem and leaves. They do not, however, develop true roots or fibrovascular bundles.

The mosses are interesting on account of the same plant having two periods in its life-history. The sexual generation, or what is usually known as the moss-plant, develops from an asexual spore and bears the organs of reproduction in the upper portion, and from which, after fertilization, the asexual generation bearing the capsule is produced. From the latter arise asexual spores which, on germination, give rise to the first or sexual generation.

V FERN-LIKE PLANTS.

The fern-like plants, or Pteridophyta, are distinguished from the mosses by possessing not only stems and leaves but roots also. They are also known as vascular cryptogams because they develop both tracheids and sieve-tubes. The life-history of the plants of this group is similar to that of the mosses; the sexual generation, however, consists of a rather diminutive plant, from the egg cell of which, after fertilization, develops a rather large perennial plant consisting of rhizome, roots, and prominent leaves, on the latter of which are borne the sporangia containing asexual spores, and from which, on germination, arises the first or sexual generation consisting of a more or less undifferentiated thallus.

The vascular cryptogams include four prominent

orders, representatives of all of which are found in the United States. They are (1) the Filicales, which include the ferns; (2) the Salviniales; (3) the Equisetales, which include the horsetails or scouring rushes, and (4) the Lycopodiales, which include the club-mosses or Lycopodiums.

LYCOPODIUM.

The spores of *Lycopodium clavatum*, and of other species of *Lycopodium* (Fam. Lycopodiaceæ), moss-like perennial herbs indigenous to Europe, Asia, North America and Central America. The spores are obtained from the ripened cones by shaking the fruiting tops, and the extraneous matter removed by sieving. The principal sources of supply of Lycopodium are Germany, Russia and Switzerland.

Description.—A light-yellow, very mobile powder, nearly inodorous and tasteless, floating upon water and not wetted by it, but sinking on being boiled with it, and burning quickly when thrown into a flame.

Spores tetrahedral, from 25 to 40 μ in diameter, with one convex side, the surface being delicately reticulate.

Constituents.—Fixed oil about 50 per cent.; traces of a volatile alkaloid; cane sugar about 2 per cent.; ash 4 to 5 per cent.

Adulterants.—Lycopodium is sometimes admixed with pine pollen, starchy materials, and various inorganic substances, as sulphur, talc and gypsum.

ASPIDIUM (Male Fern).

The rhizome and stipes of *Dryopteris* (*Aspidium*) *Filix-mas*, and *Dryopteris* (*Aspidium*) *marginalis* (Fam. Polypodiaceæ), perennials, of which *D. Filix-mas* is more widely distributed, being indigenous to Europe, Asia, North America, west of the Rocky Mountains, and in the Andes of South America; *D. marginalis*

occurring in the Eastern and Central United States and extending north to Prince Edward's Island. The rhizome is collected in early autumn, the fronds cut off, leaving the lower portions or stipes attached to the rhizomes; the dead portions of the rhizomes with the chaff are removed; sometimes the stipes are separated and the periderm removed. The drug is carefully dried and preserved and not kept longer than one or two years.

Description.—Of horizontal or oblique growth, 5 to 15 cm. long and 1 to 2·5 cm thick, mostly covered with nearly cylindrical, slightly curved stipe-remnants, which are about 25 mm. long and 5 to 10 mm. thick, between which is a dense mass of dark-brown, glossy, transparent and soft-chaffy scales; internally spongy, pale green, becoming brownish with age; in transverse section showing an interrupted circle of about six (*Dryopteris marginalis*) or seven to ten (*Dryopteris Filix-mas*) groups of fibrovascular tissue, each of which is surrounded by an endodermis-like layer; odor slight, taste acrid, somewhat bitter and nauseous.

Constituents.—Filicic acid 5 to 8 per cent., being contained apparently in greatest abundance in rhizomes collected in autumn, and readily decomposing with the formation of filicin, an inactive but crystalline anhydride; volatile oil; tannin about 10 per cent.; fixed oil about 6 per cent.; resin, etc.

Allied Plants.—The rhizome of *Dryopteris spinulosum* appears to possess properties similar to the official drug; it somewhat resembles that of *D. Filix-mas*, but is distinguished by the chaffy scales possessing marginal secretion hairs.

Adulterants.—The rhizomes of other ferns, as of *Onoclea sensibilis*, are sometimes substituted for those of the true drug.

CHAPTER II: POWDERED VEGETABLE DRUGS.

INTRODUCTORY.

Inasmuch as a large proportion of vegetable drugs frequently occur in the market in a more or less powdered condition, it becomes of first importance to be able to identify them as well as to determine their quality in this form. Without a microscopical examination or chemical analysis this would then depend on physical tests alone, as of color, odor and taste. With some drugs, tests based on these properties would be of more or less value, particularly those containing aromatic and bitter principles; yet it would soon be found that a more detailed examination would be required to determine their degree of purity or even to identify them with certainty in all cases.

Classification.—It was not considered desirable to give a detailed description of the powder under each drug in the chapter on crude drugs, for the reason that the identity of the drug as a root, rhizome, bark, etc., is lost, and in the examination of a given powder it is usually found advantageous to compare it with those powders having a similar color. By a careful comparison of the powders of the vegetable drugs, it has been found that according to their colors they form five main groups, as follows: (1) whitish powders, (2) yellowish powders, (3) reddish powders, (4) brownish powders, (5) greenish powders. These groups are then subdivided according to the kinds of cells and the nature of the cell-walls and cell-contents.

Reagents.—For the rapid differentiation and study of the characteristic tissues and cell-contents of the pow-

der it is necessary to employ reagents which render the particles more or less transparent and at the same time do not destroy their characteristics; the most satisfactory reagent of this kind for general purposes is an aqueous solution of chloral or a solution of chloral and glycerin; about a milligramme of the powder is mounted in a few drops of this solution, the preparation is gently heated, then allowed to cool, and examined; if it is not sufficiently transparent, it is heated again. The reagent causes a swelling of the cell-wall and is not applicable in the study of the starch grains, but it is very useful in the study of mechanical tissues, hairs and calcium oxalate.

After having determined the presence of starch, a separate mount of the powder in water is made and the size and markings of the grains noted.

For the examination of more or less lignified cells, mounts are made, either in phloroglucin or aniline sulphate solution; in some cases it is advantageous to apply these solutions after the specimen has been previously treated with chloral. Sometimes it is desirable to study the mechanical cells more closely, and Schulze's macerating fluid or sulphuric acid may be used for isolating them.

Examination.—All powders contain a greater or less amount of fragments of walls and other materials which are more or less alike in the different powders, and it is important that this fact be borne in mind in order that attention may be especially directed to those elements of the powder which have a diagnostic value. The latter are relatively few in number, easily identified and the distinguishing features readily determined in nearly all cases. And it is for this reason that separate illustrations are not considered necessary for the individual powders. The plates in Part IV of this book

illustrating the different kinds of starch grains, calcium-oxalate crystals, plant hairs, stone cells, etc., will be found of assistance in this connection.

KEY FOR THE STUDY OF POWDERS.

Powders of a Greenish Color.

I. *Crystals of Calcium Oxalate present.*

A. Calcium-oxalate crystals rosette-shaped.

a. Secretion and non-secretion hairs present.
Cystoliths of calcium carbonate . . . 1. Cannabis Indica
Twisted non-secretion hairs . . . . 2. Eriodictyon
Isodiametric stone cells . . . . 3. Galla
Large multicellular secretion hairs . . . . . 4. Humulus
Numerous pollen grains . . . . 5. Insect Powder
Secretion hairs few . . . . 6. Stramonii Folia

b. Secretion hairs wanting.
Hairs with slight projections . . . . 7. Pilocarpus

c. Secretion and non-secretion hairs wanting.
Sphere crystals of a carbohydrate . . . . 8. Buchu
Calcium-oxalate crystals 1–2 μ . . . . 9. Conium
Calcium-oxalate crystals 40–60 μ . . . . 10. Chimaphila
Outer wall of epidermal cells very thick . 11. Eucalyptus
Crystal fibers . . . . 11a. Granatum

B. Calcium oxalate in monoclinic prisms.

a. Secretion and non-secretion hairs present.
Calcium-oxalate crystals about 10 μ . . 12. Hyoscyamus

b. Only non secretion hairs present.
Characteristic stone cells . . 13. Cardamomum (Ceylon)
Crystal fibers . . . . 14. Hamamelis
Fragments reddish with alkalies . . . . . . 15. Senna
Non-secretion hairs few . . . . 16. Uva Ursi

c. Secretion and non-secretion hairs wanting.
Epidermal cells with papillæ . . . . 17. Coca
Few fragments of tissues . . . . . 18. Guaiaci Resina
Few crystal fibers and non-secretion hairs . 19. Uva Ursi

C. Calcium oxalate in crystal fibers.
Rosette-shaped crystals numerous . . . . 20. Granatum
Crystal fibers few . . . . 20a. Uva Ursi

D. Calcium oxalate in cryptocrystalline crystals.
Non-secretion and secretion hairs . 21. Belladonnæ Folia

I *Calcium-Oxalate Crystals wanting.*

A. Cystoliths of calcium carbonate present.

Secretion and non-secretion hairs . . 22. Cannabis Indica
Starch grains numerous . . . . 23. Spigelia

B. Calcium carbonate crystals wanting.

a. Secretion and non-secretion hairs present.

α Fragments of pappus present.

Pollen grains 10–20 μ . . . . 24. Eupatorium
Pollen grains about 25 μ . . . . 25. Grindelia

β Fragments of pappus wanting.

1. Secretion hairs with one to two-celled head.

Non-secretion hairs characteristic . . . . . 26. Digitalis

2. Secretion hairs with one to eight-celled head.

Odor characteristic . . . . 27. Hedeoma
Non-secretion hairs twisted . . . . 28. Marrubium
Odor characteristic . . . . 29. Mentha Piperita
Non-secretion hairs characteristic . . . . . . 30. Salvia

b. Secretion hairs wanting.

α With non-secretion hairs.

Pollen grains and fragments of seeds . . . . 31. Lobelia
Pollen grains and fragments of seeds wanting,
32. Scoparius

β Non-secretion hairs wanting.

Starch grains present . . . . 33. Cardamomum
Without starch grains . . . . 34. Staphisagria

Powders of a Yellowish Color.

I. ***Fragments of Vegetable Tissue present.***

A. Containing starch.

a. With calcium-oxalate crystals.

α In rosette-shaped crystals.

Crystal fibers . . . . 35. Frangula
Isodiametric stone cells . . . . 36. Galla (Aleppo)
Starch grains swollen . . . . 37. Jalapa
Calcium-oxalate crystals 50–100 μ . . . . 38. Rheum

β In monoclinic prisms.

Characteristic starch grains . . . . 39. Calumba
Starch grains swollen . . . . 40. Curcuma
Crystal fibers . . . . 41. Frangula
Long sclerenchymatous fibers . . . . . . 42. Gelsemium
Tracheæ with bordered pores . . . . 43. Quassia

γ In crystal fibers.

Without cork fragments . . . 44. Glycyrrhiza (Russian)

With cork fragments . . . . 44a. Glycyrrhiza (Spanish)
δ In raphides.
Tracheids with bordered pores . . . . . 45. Ipecacuanha
Long sclerenchymatous fibers . . . 46. Phytolaccæ Radix
Thickened endodermal cells . . . . 47. Veratrum Viride
b. Calcium oxalate wanting.
α Stone cells present.
Characteristic starch grains . . . . 48. Calumba
β Stone cells wanting.
1. Starch grains 15–30 μ in diameter.
With yellow oil-secretion cells . . . . 49. Zingiber
2. Starch grains 5–15 μ in diameter.
Long non-lignified bast fibers . . . . 50. Mezereum
Ducts large . . . . 51. Pareira
Lignified sclerenchymatous fibers . . . . . 52. Serpentaria
3. Starch grains less than 5 μ in diameter.
Crystals of alkaloids with sulphuric acid . . 53. Hydrastis
4. Starch grains altered.
Large cells with swollen grains . . . . . . 53a. Curcuma

B. Starch grains few or none.
a Calcium-oxalate crystals present.
α In rosette-shaped crystals.
Non-secretion hairs . . . . 54. Anisum
Pollen grains . . . . 55. Calendula
Non-secretion hairs wanting . . . . 56. Fœniculum
β In monoclinic prisms.
Crystals 15–20 μ . . . . 57. Aurantii Amari Cortex
Crystals 20–30 μ . . . . 57a Aurantii Dulcis Cortex
γ In raphides.
Crystals 0·1–1 mm. long . . . . 58. Scilla
b. Calcium-oxalate crystals wanting.
α. Stone cells present.
Stone cells containing air . . . . 59. Colocynthis
Not pungent . . . . 60. Linum
Pungent, with yellowish pigment cells . 61. Sinapis Alba
Pungent, with brownish-red pigment cells,
62. Sinapis Nigra
β Stone cells, if present, not well developed.
1. Containing pollen grains.
Fragments of pappus . . . . 63. Arnicæ Flores
Pollen grains prickly, with three pores . . 64. Calendula
Pollen grains nearly smooth . . . . 65. Crocus
Bitter, ducts scalariform . . . . 66. Chirata

2. Pollen grains wanting.
 * Fibrovascular tissue present.
Containing inulin masses . . . . 67. Lappa
Sclerenchymatous fibers numerous . . . . . . 68. Senega
 ** Fibrovascular tissue wanting.
Few or no fragments of vegetable tissues . 69. Cambogia
Large multicellular secretion hairs . . . 70. Lupulinum
Tetrahedral spores . . . . 71. Lycopodium

II. *Few or No Fragments of Vegetable Tissues.*

A. Giving off odor of sulphur dioxide when burned.
Rounded masses in chains . . . . . . 72. Sulphur Lotum
Rounded masses in irregular groups,
73. Sulphur Præcipitatum

B. No odor of SO_2 on burning.

a. Nearly colorless in glycerin mount.
Transparent, irregular masses . . . . 74. Mastiche

b. Yellowish in glycerin mount.
 α Containing oil globules.
Irregular masses . . . . 75. Scammonium
 β Transparent or translucent.
Soluble in cold alcohol . . . . 76. Colophony
Insoluble in cold alcohol . . . . 77. Sandarac
Reddish with alkalies . . . . 78. Aloes (Cape)
 γ More opaque.
Light or grayish particles . . . . 79. Ammoniac
Yellowish particles . . . . 80. Cambogia

Powders of a Brownish Color.

I. *Fibrovascular Tissue present.*

A. Containing starch.

a. Calcium-oxalate crystals present.
 α Crystals rosette-shaped.
 1. Sclerenchymatous fibers numerous.
 * Containing resin or tannin masses.
 † Fibers with thick walls and strongly lignified.
Sclerenchymatous fibers few . . . 81. Belladonnæ Radix
Starch grains 4–20 μ . . . . 82. Gossypii Radicis Cortex
Starch grains 3–7 μ, compound . . . . 83. Rubus
Starch grains 15–30 μ . . . . 84. Stillingia
 †† Fibers with relatively thin walls and not strongly lignified.
Modified bast fibers . . . . 85. Euonymus
 ** No resin or tannin masses.
Crystals about 25 μ . . . . 86. Althæa

2. Sclerenchymatous fibers wanting.
* Containing tannin.
† With oil-secretion reservoirs.

Starch grains ellipsoidal . . . . 87. Fruit of Cloves
Reddish-brown tannin masses . . . . 88. Pimenta

†† Oil-secretion reservoirs wanting.

Light-brown tannin masses . . . . 89. Galla
Calcium oxalate 45–70 μ . . . . 90. Geranium
Calcium oxalate 50–100 μ . . . . 90a. Rheum

** Without tannin.

Cryptocrystalline crystals . . . . 91. Belladonnæ Radix

β Crystals in monoclinic prisms and pyramids.

Crystal fibers . . . . 92. Frangula
Sclerenchymatous fibers characteristic . . 93. Krameria
Crystal fibers and stone cells . 93a. Rhamnus Purshiana

γ Crystal fibers present.
1. Sclerenchymatous fibers strongly lignified.
* Colored reddish with alkalies.

Without stone cells . . . . 93b. Frangula
With stone cells . . . . 94. Rhamnus Purshiana

** Not colored reddish with alkalies.

Stone cells characteristic . . . . 95. Quercus Alba
Stone cells characteristic . . . . 96. Prunus Virginiana

2. Sclerenchymatous fibers not strongly lignified.

Fragments of ducts . . . . 97. Calamus
No fragments of ducts . . . . 98. Ulmus

δ Calcium oxalate in raphides.
1. Raphides not more than 10 μ long.

No fragments of ducts . . . . 99. Cinnamomum
Fragments of ducts present . . . . . . 100. Sarsaparilla

2. Raphides 40–45 μ long.

Spherical starch grains 3–12 μ . . . . . . 101. Convallaria
Thick-walled parenchyma with simple pores . . . . 102. Cypripedium
Ellipsoidal starch grains 7–20 μ . 103. Veratrum Viride

ϵ Calcium oxalate in cryptocrystalline crystals.

Sclerenchymatous fibers few . . 103a. Belladonnæ Radix
Bast fibers characteristic . . . . 104. Cinchona

b. Calcium-oxalate crystals wanting.

a With non-secretion hairs.

Greenish fragments with sulphuric acid, 105. Strophanthus

β Non-secretion hairs wanting.
1. Sclerenchymatous fibers present.
* Ducts numerous.
† Starch grains 2–5 μ in diameter.

Ducts large and with bordered pores . . 106. Cimicifuga
Thick-walled parenchyma with simple pores,
107. Cypripedium
Scalariform ducts . . . . 108. Leptandra
Spiral ducts . . . . 109. Spigelia
†† Starch grains 5–15 or 20 μ in diameter.
Fragments of milk vessels . . . . . . 110. Apocynum
Raphides 45 μ long . . . . 111. Convallaria
Raphides 6–8 μ long . . . . 112. Sarsaparilla
Ducts with bordered pores . . . . 113. Sumbul
Stone cells characteristic . . . . 114. Valeriana
** Ducts few or none.
Characteristic bast fibers . . . . 115. Cinchona
Raphides about 5 μ long . . . . . . 116. Cinnamomum
Short sclerenchymatous fibers . . . . 117. Coffee
Starch grains 7–20 μ, compound . . . . . 118. Sassafras
2. Sclerenchymatous fibers wanting.
* Stone cells present.
† Giving tannin reaction with ferric salts.
Stone cells characteristic . . . . 119. Cacao
Altered starch grains . . . . 120. Guarana
Stone cells characteristic . . . . 121. Piper
Thick-walled endosperm cells . . . 122. Colchici Semen
†† Not becoming blue or green with ferric salts.
Starch grains 4–12 μ . . . . 123. Aconitum
Starch grains 25–40 μ . . . . 124. Physostigma
** Stone cells wanting.
Stone cells few . . . . 125. Aconitum
Starch grains 7–20 μ . . . . 126. Colchici Cormis
Altered starch grains . . . . 127. Guarana
Amylo-dextrin grains . . . . 128. Macis
Numerous oil globules . . . . 128. Myristica
Few fragments of vegetable tissues . . . . 129. Opium
Starch grains 5–12 μ . . . . 130. Podophyllum

B. Starch grains few or none.
a. Containing calcium oxalate.
α In rosette-shaped crystals.
1. Small crystals in aleurone grains.
With non-secretion hairs . . . . 131. Anisum
Calcium oxalate 0·5–1 μ . . . . 132. Carum
Calcium oxalate 3–7 μ . . . . 133. Coriandrum
Calcium oxalate 1–2 μ . . . . 134. Fœniculum
2. Crystals not less than 10 μ in diameter.
* Pollen grains numerous.

Crystals numerous . . . . 135. Caryophyllus
Crystals few . . . . 136. Insect Powder
** Pollen grains few.
† Ducts present.
Secretion and non-secretion hairs . . . . . . 137. Cusso
†† Ducts wanting.
Stone cells few . . . . 138. Viburnum Opulus
Stone cells numerous . . . 139. Viburnum Prunifolium
β Calcium oxalate in monoclinic prisms.
1. Numerous seeds.
Characteristic odor . . . . 140. Vanilla
2. Seeds wanting.
Stone cells few . . . . 141. Viburnum Opulus
Stone cells numerous, characteristic,
142. Viburnum Prunifolium
Numerous oil globules . . . . . . 143. Xanthoxylum
γ Calcium oxalate in crystal fibers.
Stone cells characteristic . . . . . . 144. Quercus Alba
b. Calcium oxalate wanting.
α Containing pollen grains.
Non-secretion hairs numerous. . . . 145. Arnicæ Flores
Spherical pollen grains . . . . 146. Crocus
Non-secretion hairs few . . . . 147. Santonica
β Pollen grains wanting.
1. Stone cells numerous.
Fragments wine-colored with sulphuric acid . 149. Cubeba
2. Stone cells wanting.
Non-lignified intermediate fibers . . . . 150. Gentiana
Few fragments of tissues . . . . 151. Opium
Ducts reticulate . . . . 152. Pyrethrum
Fragments of milk-vessels . . . . 153. Taraxacum
Ducts spiral, annular or with simple pores . 154. Triticum

II. *Without Fibrovascular Tissue.*

A. With cellular tissues.
Spores about 7 μ . . . . 155. Ustilago
Numerous oil globules . . . . 156. Ergota
Few or no fragments of tissues . . . . 157. Opium

B. Without cellular tissues.
a. Possessing oil.
Grayish fragments . . . . 158. Asafetida
Yellowish or yellowish-brown fragments . 159. Myrrha
b. Without oil.
α Remain opaque in glycerin.

Characteristic odor . . . . 160. Aloes (Socotrine)
Characteristic odor . . . . 161. Benzoinum
Grayish opaque fragments . . . . . . 162. Elaterinum
Fragments of woody tissues . . . . . 163. Goa Powder
Brownish angular masses . . . . 164. Lactucarium

β More or less translucent in glycerin.

Dark Brown . . . . 165. Aloes (Curacao)
Yellowish brown . . . . 166. Aloes (Socotrine)
Characteristic odor . . . . 166a. Benzoinum
Few fragments of tissues . . . . 167. Catechu
Fragments translucent deep red . . . . . . 168. Kino

Powders of a Reddish Color.

I. *Containing Starch.*

Very light pink, crystals present . . . . . 169. Quillaja
Reddish, crystals wanting . . . . . . 170. Sanguinaria

II. *Without Starch.*

A. Stone cells present.

Characteristic stone cells . . . . 171. Capsicum
Characteristic secretion hairs . . . . . 172. Rhus Glabra

B. Stone cells wanting.

a. With wood fibers.

Coloring principle soluble in water . 173. Hæmatoxylon
Coloring principle insoluble in water, 174. Santalum Rubrum

b. Wood fibers wanting.

Blue with sulphuric acid . . . . 175 Crocus
Containing tannin . . . . 176. Kino
Large secretion hairs . . . . 177. Lupulinum
Characteristic odor . . . . 178. Opium
Epidermal cells with papillæ . . . . . . 179. Rosa Gallica

Powders of a Whitish Appearance.

I. *Plant Tissues or Cell-Contents Recognizable.*

A. Containing starch.

a. Only unaltered starch grains present.

Excentral and fissured point of origin of growth, 180. Maranta Starch
Excentral and circular point of origin of growth, 181. Potato Starch
Polygonal grains . . . . 182. Corn Starch
Small, polygonal, compound grains . . 183. Rice Starch
Ellipsoidal, point of origin of growth indistinct, 184. Wheat Starch

b. Altered and unaltered starch grains present.
Agglutinates with water . . . . 185. Dextrin
c. Plant tissues in addition to starch.
α Do not readily dissolve or swell in cold water.
Characteristic starch grains . . . . 186. Corn Meal
Characteristic starch grains . . . . 187. Corn Bran
Characteristic starch grains . . . . 188. Wheat Flour
Characteristic starch grains . . . 189. Wheat Middlings
Lignified hairs, starch grains few . . . 190. Nux Vomica
Characteristic starch grains . . . . 191. Orris Root
Crystals of calcium oxalate . . . . 191a. Quillaja
β Soluble or swelling in cold water to form a sticky mass.
Few plant tissues . . . . 192. Acacia
Starch and fragments of ducts . . . . 193. Tragacantha

B. Without starch.

a. Calcium oxalate present.
Raphides 0·1 to 1 mm. . . . . 194. Scilla
b. Calcium oxalate wanting.
Characteristic lignified hairs . . . . . 195. Nux Vomica

II. *Absence of Plant Tissues.*

A. Soluble in water.

Monoclinic prisms . . . . 196. Saccharum

B. Insoluble in water.

a. Soluble in alcohol.
Irregular fragments . . . . 197. Camphora
b. Insoluble in alcohol.
α Reddish color with sulphuric acid.
Gritty, monoclinic prisms of various sizes, 198. Saccharum Lactis
β No color-reaction with sulphuric acid.
1. Soapy feel.
Broken crystals . . . . 199. Talc
2. Soluble in acetic acid.
* With effervescence.
In prisms or irregular angular fragments, 200. Precipitated Calcium Carbonate
An amorphous powder . . . . 201. Prepared Chalk
Rhombic crystals or irregular fragments, 202. Barium Carbonate
** Without effervescence.

Rounded masses . . . . 203. Heavy Magnesia
Very light . . . . 204. Light Magnesia

3. Insoluble in acetic acid.

* Soluble in nitric acid.

Tetragonal or cubical crystals,
205. Precipitated Calcium Phosphate
Acicular crystals . . . . 206. Calcium Sulphate
Rhombic prisms or crystals of various sizes,
207. Barium Sulphate
Irregular fragments . . . . 208. Terra Alba

POWDERS OF A GREENISH COLOR.

In this group are included all those drugs which in a powdered condition are of a light-green, yellowish-green or dark-green (sap-green) color. Most of the powders of the leaves and herbs belong to this class.

I. CRYSTALS OF CALCIUM OXALATE PRESENT.

A. CALCIUM OXALATE CRYSTALS ROSETTE-SHAPED.

a. Secretion and Non-Secretion Hairs Present.

1. **Cannabis Indica.**—Dark green; non-secretion hairs one-celled, more or less curved, with numerous slight projections, and sometimes with cystoliths of calcium carbonate; secretion hairs two kinds — either with short unicellular or multicellular stalks and eight to sixteen-celled glandular heads; calcium oxalate crystals rosette-shaped, about 20 μ in diameter; numerous oil globules and resin fragments; few nearly spherical pollen grains 25 to 35 μ in diameter, with numerous centrifugal projections, in among club-shaped unicellular hairs of style; ducts spiral or with simple or bordered pores; sclerenchymatous fibers long, thin-walled, non-lignified, and with few simple pores; laticiferous vessels with reddish-brown contents. When mature seeds are present, palisade-like stone cells occur, which are very thick-walled, and have a small lumen.

2. **Eriodictyon.**—Dark green; calcium oxalate crystals rosette-shaped, 20 to 25 μ in diameter; non-secretion hairs one-celled and thick-walled; secretion hairs with one-celled stalk and six to eight-celled glandular head. In powder of the stems occur: ducts, which are spiral or have simple or bordered pores; sclerenchymatous fibers either non-lignified and thin-walled, or lignified and thick-walled, and with numerous simple pores; pith cells somewhat tabular, thick-walled, slightly lignified, and with numerous simple pores.

3. **Galla** (Chinese or Japanese).—Grayish green; calcium oxalate crystals about 20 μ in diameter; starch grains about 40 μ in diameter; non-secretion hairs; milk vessels accompanying ducts; mounts in glycerin may show acicular crystals of gallic acid.

4. **Humulus.**—Light green; calcium-oxalate crystals rosette-shaped, 10 to 15 μ in diameter; non-secretion hairs unicellular, more or less bent, thin-walled, 0·2 to 0·3 mm. long; secretion hairs of two kinds, either with a three-celled stalk and a nearly colorless, multicellular, glandular head about 50 μ in diameter, or with a short four-celled stalk and a multicellular, bright yellow, glandular head 0·1 to 0·3 mm. in diameter.

5. **Insect Powder [Persian (*Pyrethrum roseum*)].**—Grayish green; with numerous rounded and prickly pollen grains, 25 μ; some few crystals 2 to 8 μ in diameter, in stone cells or in parenchyma adjoining; sclerenchyma-fibers about 20 μ in diameter and 100 to 160 μ long; fragments of T-non-secretion hairs less numerous than in Dalmatian; characteristic, isolated, somewhat rounded or elliptical parenchyma cells, also occurring in papillæ-like fragments; fragments of papillæ (epidermis of corolla), acute and more numerous than in Dalmatian; secretion hairs about 50 μ in diameter, being smaller than in Dalmatian; rose-

colored fragments in chloral mounts possibly more numerous in the Persian powder.

6. **Stramonii Folia.**—Dark green; calcium oxalate in rosette-shaped crystals 10 to 20 μ in diameter; non-secretion hairs few, two to three-celled, with numerous slight centrifugal projections; secretion hairs few, stalk one to two-celled, glandular head two to four-celled.

7. **Pilocarpus.**—Dark green; epidermal cells on surface view five to six-sided, walls straight; calcium-oxalate crystals rosette-shaped, 20 to 30 μ in diameter, frequently in palisade cells and also in cells in the air spaces of the stomata; mesophyl cells frequently with reddish-brown tannin masses, turning green with ammonio-ferric sulphate solution; non-secretion hairs one-celled, thick-walled, with numerous slight centrifugal projections, 0·4 to 0·6 mm. long in *P. Jaborandi* and 40 to 60 μ long in *P. pennatifolius* and *P. microphyllus.* In *P. microphyllus* the stomata are smaller than in the other two species.

b. Secretion and Non-Secretion Hairs Wanting.

8. **Buchu.**—Light green; calcium-oxalate crystals rosette-shaped, 15 to 25 μ in diameter; epidermal cells with irregular masses or sphere-crystals of a carbohydrate 30 to 50 μ in diameter, and with walls modified to mucilage; oil globules numerous.

9. **Conium.**—Grayish green or yellowish brown; calcium-oxalate crystals rosette-shaped, 1 to 2 μ in diameter, those in aleurone grains about 5 μ in diameter; parenchyma with chloroplastids and starch grains 2 to 4 μ in diameter; sclerenchymatous fibers long, thin-walled, with numerous simple oblique pores; intermediate fibers with reticulated walls; cells of pericarp nearly isodiametric, yellowish, irregularly

thickened, somewhat collenchymatous; oil globules numerous.

10. **Chimaphila.**—Dark green; calcium oxalate in rosette-shaped crystals 40 to 60 μ in diameter; mesophyl with irregular reddish-brown tannin masses.

11. **Eucalyptus.**—Dark green; calcium oxalate in rosette-shaped crystals or monoclinic prisms 15 to 25 μ in diameter; outer wall of epidermal cells about 20 μ thick. In leaves from younger parts of the tree the outer wall of the epidermal cells is 5 to 8 μ thick.

11a. **Granatum.**—(See No. 20.)

B. CALCIUM OXALATE IN MONOCLINIC PRISMS.

a. Secretion and Non-Secretion Hairs Present.

12. **Hyoscyamus.**—Dark green; calcium oxalate in single or twin monoclinic prisms about 10 μ in diameter, occasionally in rosette-shaped crystals; non-secretion hairs numerous, one to five-celled; secretion hairs numerous, of three different kinds, stalks one to four-celled, glandular heads one to many-celled.

b. Only Non-Secretion Hairs Present.

13. **Cardamomum.**—(See No. 33.)

14. **Hamamelis.**—Dark green; calcium oxalate in monoclinic prisms 7 to 20 μ in diameter, frequently in crystal fibers; non-secretion hairs one-celled, about 0·5 mm. long, more or less curved, thick-walled, with yellowish-brown contents, arranged in groups of about fifteen, and spreading from the base; mesophyl with irregular tannin masses; sclerenchymatous fibers thick-walled, lignified and with simple pores.

15. **Senna.**—Light green; non-secretion hairs 0·1 to 0·2 mm. long, one-celled, thick-walled, the wall of the upper part strongly cutinized, with numerous slight centrifugal projections; calcium-oxalate crystals rosette-

shaped, or occasionally in monoclinic prisms, 10 to 20 μ in diameter; fragments colored reddish with potassium hydrate solution.

The powder of Indian senna (*Cassia angustifolia*) is dark green and has relatively few non-secretion hairs. In the powder of Argel Leaves (*Solenostemma Argel*) (Fam. Asclepiadaceæ) the non-secretion hairs are three to four-celled. In the leaves of *Castanea dentata* (Fam. Fagaceæ) the non-secretion hairs are relatively few, 0·2 to 0·5 mm. long, nearly smooth, thick-walled, occasionally in groups of three to eight and spreading from the base; the calcium-oxalate crystals are numerous, rosette-shaped or in monoclinic prisms, 10 to 35 μ in diameter, occasionally in crystal fibers; the parenchymatous cells contain irregular yellowish-brown tannin masses which are colored blue with ammonio-ferric alum solution.

16. **Uva Ursi.**—(See No. 19).

c. Secretion and Non-Secretion Hairs Wanting.

17. **Coca.**—Dark green; calcium oxalate in monoclinic prisms 3 to 10 μ in diameter; walls of under epidermal cells extended as minute papillae.

18. **Guaiaci Resina.**—Dark green; numerous lemon-yellow or dark-brown resin masses, which when mounted in chloral have a wine-colored halo around them; few fragments of tissues with characteristic sclerenchymatous cells and fibers; few crystals of calcium oxalate in monoclinic prisms.

19. **Uva Ursi.**—Yellowish green; calcium oxalate in monoclinic prisms 7 to 10 μ in diameter, frequently in crystal fibers; non-secretion hairs few, somewhat curved, one-celled, thick-walled, longitudinally striate; mesophyl with irregular yellowish-brown tannin masses; characteristic sclerenchymatous fibers.

C. CALCIUM OXALATE IN CRYSTAL FIBERS.

20. **Granatum.**—Dark green; crystal fibers containing rosette-shaped crystals and monoclinic prisms of calcium oxalate about 15 μ in diameter; sclerenchymatous cells non-lignified, thick-walled, with distinct lamellæ, simple pores and branched canals; starch grains spherical, 5 to 7 μ in diameter; some parenchymatous cells with marked centripetal thickenings, others with irregular tannin masses. The powder of the root bark is free from chloroplastids; the cork cells are more numerous and the sclerenchymatous cells more irregular in shape.

20a. **Uva Ursi.**—(See No. 19).

D. CALCIUM OXALATE IN CRYPTOCRYSTALLINE CRYSTALS.

21. **Belladonnæ Folia.**—Dark green; calcium oxalate in cryptocrystalline crystals, occasionally in raphides or rosette-shaped crystals; non-secretion hairs few, simple, two to five-celled; secretion hairs few, of two kinds, stalks one to three-celled, glandular heads one to many-celled.

II. CALCIUM-OXALATE CRYSTALS FEW OR WANTING.

A. CYSTOLITHS OF CALCIUM CARBONATE PRESENT.

22. **Cannabis Indica.**—(See No. 1).

23. **Spigelia.**—An adulterant of Spigelia contains calcium carbonate in special cells of the cortex.

B. CALCIUM-CARBONATE CRYSTALS WANTING.

a. Secretion and Non-Secretion Hairs Present.

α FRAGMENTS OF PAPPUS PRESENT.

24. **Eupatorium.**—Dark green; non-secretion hairs of two kinds, two to eight-celled, thin-walled, finely

striate, one kind with acute end cell and the other with rounded end cell; secretion hairs either six to eight-celled in a double row, and glandular head two-celled, or short stalked and glandular head four to twelve-celled; pollen grains ellipsoidal, 10 to 20 μ in diameter and with numerous centrifugal projections; pappus a multicellular axis about 30 μ in diameter, with short unicellular alternate branches; ducts spiral, annular, or with bordered pores; sclerenchymatous fibers thin-walled, non-lignified, with few, simple oblique pores.

25. **Grindelia.**—Light green; ducts spiral, annular, or with bordered pores, strongly lignified; sclerenchyma fibers thin-walled, non-lignified, with numerous simple more or less oblique pores; pollen grains spherical, about 25 μ in diameter, with numerous centrifugal projections; secretion hairs depressed, globular, multicellular; numerous oil globules and resin masses; pappus a multicellular axis with minute teeth.

β FRAGMENTS OF PAPPUS WANTING.

26. **Digitalis.** — Dark green; non-secretion hairs simple, consisting of two to five superimposed cells, straight or slightly curved; secretion hairs with one-celled stalk and one to two-celled glandular head; stone cells, star-shaped hairs and calcium oxalate crystals are wanting.

27. **Hedeoma.** — Dark green; non-secretion hairs slightly curved, two to three-celled, thick-walled, with numerous slight centrifugal projections; secretion hairs with one celled stalk and eight-celled glandular head; pollen grains somewhat spherical, about 35 μ in diameter, nearly smooth; ducts spiral, with simple and bordered pores; sclerenchymatous fibers long, thin-walled, lignified, with numerous simple pores;

epidermal cells with sphere-crystals or irregular masses of a carbohydrate.

28. **Marrubium.**—Dark green; non-secretion hairs much twisted, one to seven-celled, thin-walled, smooth, frequently arranged in groups of about six or eight, and spreading from the base; secretion hairs with one-celled stalk and eight-celled glandular head; pollen grains spherical, about 25 μ in diameter, and with numerous centrifugal projections; ducts spiral, annular, or reticulate, slightly lignified; sclerenchymatous fibers thin-walled, non-lignified, and with few simple pores.

29. **Mentha Piperita.**—Dark green; non-secretion hairs one to eight-celled, thin-walled, with numerous slight projections; secretion hairs two kinds, one or three-celled stalk and one or eight-celled glandular head; pollen grains somewhat spherical, smooth, about 35 μ in diameter; ducts spiral, or with simple and bordered pores and slightly lignified; sclerenchymatous fibers thin-walled, non-lignified, with numerous oblique pores.

30. **Salvia.**—Dark green; non-secretion hairs one to six-celled, filled with air; secretion hairs numerous, of two kinds, stalks one to three-celled, glandular heads unicellular or eight-celled.

b. Secretion Hairs Wanting.

a WITH NON-SECRETION HAIRS.

31. **Lobelia.**—Dark green; non-secretion hairs one-celled, 0·3 to 0·6 mm. long, walls moderately thick, with numerous slight centrifugal projections; pollen grains ellipsoidal, smooth, 15 to 30 μ in diameter; laticiferous vessels branched; ducts spiral, scalariform and with bordered pores; sclerenchymatous fibers comparatively thin-walled, non-lignified, and with simple oblique pores.

32. **Scoparius.**—Dark green; non-secretion hairs one-celled, 0·5 to 0·7 mm. long, thick-walled; ducts spiral or double spiral, slightly lignified; sclerenchymatous fibers narrow, thin-walled and with simple pores.

β NON-SECRETION HAIRS WANTING.

33. **Cardamomum.**—Dark green; stone cells dark brown, slightly elongated, 15 to 25 μ in diameter, the inner wall thickened; outer epidermal cells 20 to 30 μ in diameter, elongated on surface view, inner and outer walls thickened; oil-secretion cells with suberized walls; starch grains spherical or angular, single or compound, 1 to 4 μ in diameter; monoclinic prisms of calcium oxalate few, 10 to 25 μ in diameter. The powder of pericarp and seeds is pinkish and contains, in addition, sclerenchyma fibers which are non-lignified, relatively thin-walled and with simple slightly oblique pores; ash not more than 10 per cent. The powder of Ceylon cardamom contains non-secretion unicellular hairs of the capsule, and the cells as also the starch grains and calcium oxalate crystals are larger.

34. **Staphisagria.**—Dark green; sclerenchymatous cells somewhat ovate in cross section, more or less thick-walled and non-lignified; parenchyma containing oil and aleurone.

POWDERS OF A YELLOWISH COLOR.

In this group are included all those powdered drugs which are of a light-yellow (light-yellow ochre), dark-yellow (dark-yellow ochre), lemon-yellow, bright-yellow (luminous-yellow) or yellowish-brown color. Representatives of all the different kinds of drugs are found in this group.

I. FRAGMENTS OF VEGETABLE TISSUES PRESENT.

A. CONTAINING STARCH.

a. Calcium Oxalate Present.

α IN ROSETTE-SHAPED CRYSTALS.

35. **Frangula.**—(See No. 41).

36. **Galla (Aleppo).**—Dark-yellow crystals 10 μ; starch grains 10 μ in diameter, single or sometimes in groups; stone cells; tannin; crystals of gallic acid. Chinese or Japanese galls, grayish green; crystals few, about 20 μ in diameter; starch grains about 40 μ in diameter; non-secretion hairs; milk vessels accompanying ducts; mounts in glycerin show acicular crystals of gallic acid.

37. **Jalapa.**—Dark yellow; crystals of calcium oxalate rosette-shaped, 30 to 35 μ in diameter; starch grains ellipsoidal and ovoid, with somewhat excentral lamellæ, 15 to 35 μ in diameter, one to three-compound and in some cases more or less swollen; secretion cells yellowish brown; sclerenchymatous fibers few, with simple pores.

38. **Rheum.**—Yellowish brown; crystals of calcium oxalate rosette-shaped, 50 to 100 μ in diameter; starch grains somewhat spherical, 5 to 20 μ in diameter, either single or two to four-compound; ducts few, scalariform.

β IN MONOCLINIC PRISMS.

39. **Calumba.**—(See No. 48.)

40. **Curcuma.**—Bright yellow; crystals few, 2 to 4 μ in diameter; altered starch grains (test with iodine) in irregular masses from 100 to 140 μ in diameter, having the shape of the cell in which they occur; bright-yellow oil-secretion cells; pigment dissolved out by use of solutions of chloral or chloral-glycerin, as well as when essential oils are employed; characteristic

color-reaction by treatment with sulphuric acid, or with boric acid and hydrochloric acid, and subsequent evaporation with ammonia water.

41. **Frangula.**—Yellowish brown; bast fibers lignified, much thickened, with numerous pores; crystal fibers containing small monoclinic prisms of calcium oxalate; calcium oxalate also in rosette-shaped crystals or monoclinic prisms, 5 to 20 μ in diameter; starch grains nearly spherical, about 4 μ in diameter, not numerous; parenchymatous cells with yellowish contents colored red by alkalies.

42. **Gelsemium.**—Dark yellow; ducts with simple pores; sclerenchymatous fibers long, narrow, lignified; starch grains spherical, from 4 to 8 μ in diameter; calcium oxalate in monoclinic prisms 15 to 30 μ in diameter. In the powder of the overground stem collenchymatous cells containing chloroplastids occur.

43. **Quassia.**—Light yellow; ducts large, with bordered pores; sclerenchymatous fibers long, thin-walled and with oblique pores; medullary rays with calcium oxalate in monoclinic prisms or in cryptocrystalline crystals, or with few spherical starch grains. When bark of the wood is present a few stone cells and cork cells are also present; in the bark of Surinam Quassia stone cells are numerous.

γ IN CRYSTAL FIBERS.

44. **Glycyrrhiza (Spanish).**—Bright yellow; sclerenchymatous fibers numerous; crystal fibers containing monoclinic prisms of calcium oxalate; starch grains somewhat spherical, 2 to 20 μ in diameter. Russian licorice is of a bright-yellow color and contains few or no fragments of cork.

δ IN RAPHIDES.

45. **Ipecacuanha.**—Dark yellow; tracheids with simple oblique or bordered pores, sometimes containing

starch; calcium oxalate in raphides 20 to 40 μ long; starch grains ellipsoidal, 4 to 14 μ in diameter, single or two to four-compound. In Carthagena ipecac the starch grains are uniformly larger, 4 to 15 μ in diameter.

46. **Phytolaccæ Radix.**—Dark yellow; sternutatory; fragments with long sclerenchymatous fibers and large scalariform ducts; starch grains somewhat spherical, 7 to 18 μ in diameter; calcium oxalate in raphides 30 μ long or in cryptocrystalline crystals.

47. **Veratrum Viride.**—Yellowish brown; sternutatory; ducts slightly lignified, scalariform or reticulate; sclerenchymatous fibers thin-walled, narrow, slightly lignified; calcium oxalate in raphides 45 μ long; starch grains nearly ellipsoidal, 7 to 20 μ in diameter, point of origin of growth circular or slightly cleft, grains single or two to three-compound; endodermal cells thickened on the inner tangential wall.

b. Calcium Oxalate Wanting.

α STONE CELLS PRESENT.

48. **Calumba.**—Bright yellow; stone cells containing one or more monoclinic prismatic crystals of calcium oxalate; starch grains single, irregular, 25 to 35 μ long, with excentral and distinct lamellæ.

β STONE CELLS WANTING.

1. STARCH GRAINS 15 TO 30 μ IN DIAMETER.

49. **Zingiber.**—Light yellow; starch grains ellipsoidal or somewhat ovoid, slightly beaked, 15 to 30 μ in diameter; secretion cells with suberized walls and yellowish-oily contents; ducts large, thin-walled, annular or reticulate; sclerenchymatous fibers long, thin-walled, with oblique pores. The powder of African Ginger is dark yellow or dark brown, more aromatic and pungent and has numerous fragments of cork.

2. STARCH GRAINS 5 TO 15 μ IN DIAMETER.

50. **Mezereum.**—Dark yellow; sternutatory; bast fibers numerous, long, thin-walled, non-lignified; starch grains somewhat spherical, 10 to 15 μ in diameter, single or compound.

51. **Pareira.**—Dark yellow; sclerenchymatous cells numerous, more or less thick-walled and slightly lignified; sclerenchymatous fibers slightly lignified and with oblique, simple or bordered pores; ducts nearly 0·2 mm. in diameter, short, non-lignified, and with simple pores: starch grains nearly ellipsoidal, 7 to 15 μ in diameter.

52. **Serpentaria.**—Dark yellow; ducts lignified, spiral or with simple pores; sclerenchymatous fibers lignified; parenchyma with yellowish or dark-brown contents; starch grains nearly spherical, 10 μ in diameter.

3. STARCH GRAINS LESS THAN 5 μ IN DIAMETER.

53. **Hydrastis.**—Bright yellow; ducts with simple pores; sclerenchymatous fibers short, thin-walled, with simple pores; starch grains spherical, about 4 μ in diameter.

4. STARCH GRAINS ALTERED.

53a. **Curcuma.**—(See No. 40).

B. STARCH GRAINS FEW OR NONE.

a. Calcium-Oxalate Crystals Present.

α IN ROSETTE-SHAPED CRYSTALS.

54. **Anisum.**—Yellowish brown; non-secretion hairs 25 to 100 μ long, one-celled, straight or curved, with numerous slight centrifugal projections; calcium oxalate crystals rosette-shaped, 2 to 3 μ in diameter, in aleurone grains about 6 μ in diameter; fragments of vittæ, and long, narrow, brownish epidermal cells; sclerenchymatous cells of carpophore short, with simple pores and occasional scalariform thickenings.

55. **Calendula.**—Bright yellow; epidermal cells long, narrow, with numerous globules and irregular chromoplastids, walls somewhat sinuate; pollen grains spherical, with numerous centrifugal projections, three-pored, about 40 μ in diameter; non-secretion hairs consisting of a double row of cells and with a single or two-celled apex; calcium oxalate in rosette-shaped crystals about 4 μ in diameter.

56. **Fœniculum.**—Yellowish brown; calcium oxalate in rosette-shaped crystals 1 to 2 μ in diameter, in aleurone grains 3 to 6 μ in diameter; fragments of vittæ and short, narrow, yellowish-brown epidermal cells of pericarp; sclerenchymatous fibers few, thick-walled, with oblique pores; parenchymatous cells slightly elongated or thick-walled, with numerous simple pores, occasionally reticulately thickened; oil globules numerous.

β IN MONOCLINIC PRISMS.

57. **Aurantii Amari Cortex.**—Dark yellow; parenchymatous cells either somewhat collenchymatous or with simple pores, walls 10 to 15 μ thick; calcium oxalate in monoclinic prisms 15 to 20 μ in diameter; ducts few, spiral, annular or with simple pores.

57a. **Aurantii Dulcis Cortex.**—Light brown; calcium oxalate in monoclinic prisms 20 to 30 μ in diameter; walls of parenchymatous cells about 4 μ thick.

γ IN RAPHIDES.

58. **Scilla.**—Light yellow; calcium oxalate mostly in raphides from 0·1 to 1 mm. in length; few ducts and fragments of epidermis.

b. Calcium-Oxalate Crystals Wanting.

a STONE CELLS PRESENT.

59. **Colocynthis.**—Light yellow; stone cells isodiametric, slightly thickened, non-lignified, with large simple

pores; parenchymatous cells large, thin-walled, with large simple pores. Powder containing seeds with numerous oil globules, outer epidermal cells with reticulated thickenings; stone cells nearly isodiametric or irregular, walls straight or undulate, more or less thickened, strongly lignified and with simple pores.

60. **Linum.**—(Linseed or Flaxseed Meal). Lemon-yellow; fragments of seed-coat with mucilaginous epidermal cells, light-brown tabular pigment cells, and small yellowish stone cells; parenchyma-cells thin-walled, containing oil and aleurone; starch none or not more than ten granules to a milligramme of powder; a fixed saponifiable oil not less than 30 per cent.; ash not more than 3·5 per cent.

61. **Sinapis Alba.**—Light yellow; fragments of seed-coat with mucilaginous epidermal cells, a sub-epidermal collenchymatous layer, a yellowish or nearly colorless pigment layer, and a layer of stone cells; oil globules and aleurone grains numerous; starch none or not more than ten granules to a milligramme of powder.

62. **Sinapis Nigra.**—Yellowish brown; fragments of seed-coat with mucilaginous epidermal cells, a layer of brownish-red pigment cells and a layer of stone cells; oil globules and aleurone grains numerous; starch none or not more than ten granules to a milligramme of powder.

β STONE CELLS, IF PRESENT, NOT WELL DEFINED.

1. CONTAINING POLLEN GRAINS.

63. **Arnicæ Flores.**—Yellowish brown; pollen grains spherical, with numerous centrifugal projections, three-pored, 25 to 35 μ in diameter; non-secretion hairs of three kinds—either unicellular, five or six-celled or consisting of a pair of united unicellular hairs with numerous pores on the dividing wall; secretion hairs of three kinds—either with a large unicellular stalk

and unicellular glandular head, a stalk of a single row of four cells and a one-celled glandular head, or a stalk of double row of five cells and a two-celled glandular head; pappus a multicellular axis with unicellular branches.

64. **Calendula.**—Bright yellow; characteristic tissue of petals containing oily drops; few pollen grains; colored brownish with sulphuric acid.

65. **Crocus.** — Orange-red; glycerin mount colored deep orange; few, nearly smooth, nearly spherical pollen grains (85–100 μ); papillæ of stigma; coloring principle soluble in water and not in fatty oils, being the reverse in capsicum; with sulphuric acid fragments become blue immediately.

66. **Chirata.**—Dark yellow; ducts spiral, scalariform or with simple pores; sclerenchymatous fibers long, narrow, thick-walled, more or less lignified, and with oblique pores; parenchymatous cells of pith large, slightly lignified, and with numerous simple pores; pollen grains oblong or ellipsoidal, very prickly, about 35 μ in diameter; collenchymatous cells with yellowish-brown resin and tannin masses.

2. POLLEN GRAINS WANTING.

* FIBROVASCULAR TISSUE PRESENT.

67. **Lappa.**—Light yellow; parenchymatous cells with irregular crystalloidal masses of inulin; ducts few, reticulate, sometimes associated with few narrow sclerenchymatous fibers.

68. **Senega.**—Dark yellow; odor penetrating; slightly sternutatory; sclerenchymatous fibers thick-walled, non-lignified, with oblique simple pores; ducts short, lignified, with simple and bordered pores; medullary-ray cells somewhat lignified, with large simple pores. Quillaja is distinguished from senega by having large

monoclinic pyramids of calcium oxalate, starch and numerous lignified bast fibers and stone cells.

** FIBROVASCULAR TISSUE WANTING.

69. **Cambogia.**—Bright yellow; sternutatory; containing few or no starch grains. Not more than 25 per cent. should be insoluble in alcohol; ash not more than 3 per cent.

70. **Lupulinum.**—(See No. 177).

71. **Lycopodium.**—Light yellow; spores tetrahedral, delicately reticulate, 25–40 μ in diameter.

II. FEW OR NO FRAGMENTS OF VEGETABLE TISSUES.

A. GIVING OFF ODOR OF SULPHUR DIOXIDE WHEN BURNED.

72. **Sulphur Lotum.**—In small chain-like masses in glycerin mounts.

73. **Sulphur Præcipitatum.**—Small rounded masses in irregular groups in glycerin mounts.

B. NO ODOR OF SULPHUR DIOXIDE WHEN BURNED.

a. Nearly Colorless in Glycerin Mount.

74. **Mastiche.**—Transparent irregular masses.

b. Yellowish in Glycerin Mount.

α CONTAINING OIL GLOBULES.

75. **Scammonium.**—Irregular masses.

β TRANSPARENT OR TRANSLUCENT.

76. **Colophony.**—Irregular masses, soluble in cold alcohol (95 per cent.) forming a straw-colored liquid, which becomes milky white on addition of water; on heating fragments of resin in water they melt, run together and form a sticky mass.

77. **Sandarac.**—Almost insoluble in alcohol (95 per cent.), the solution remaining almost colorless; the fragments do not melt when heated with water.

78. **Aloes (Cape).**—In glycerin mount some fragments are conchoidal; the particles become clear and dissolve, leaving a few colorless lens-shaped or fine acicular crystals. The latter are more abundant in the Barbadoes aloes.

γ MORE OPAQUE.

79. **Ammoniac.** — Irregular, faint - yellow, opaque masses, made up of small, whitish or grayish particles.

80. **Cambogia.**—Irregular, bright-yellow masses, made up of small yellow particles.

POWDERS OF A BROWNISH COLOR.

This group includes all those powdered drugs which have a light-brown (raw sienna or raw umber), dark brown (Vandyke brown), blackish-brown (sepia), or grayish-brown color. This is the largest group and includes most of the powdered roots, rhizomes and barks, together with a few flowers, fruits and seeds.

I. FIBROVASCULAR TISSUES PRESENT.

A. CONTAINING STARCH.

a. Calcium-Oxalate Crystals Present.

a CRYSTALS, ROSETTE-SHAPED.

1. SCLERENCHYMATOUS FIBERS NUMEROUS.

* CONTAINING RESIN OR TANNIN MASSES.

† *Fibers with Thick Walls and Strongly Lignified.*

81. **Belladonn Radix.**—(See No. 91.)

82. **Gossypii Radicis Cortex.**—Light brown; bast fibers long, narrow, thick-walled, lignified; starch grains somewhat spherical, 4 to 20 μ in diameter, single or

compound; parenchymatous cells with irregular yellowish and reddish tannin masses; calcium-oxalate crystals rosette-shaped, about 20 μ in diameter.

83. **Rubus.**—Light brown, bast fibers numerous, long, thick-walled, lignified; calcium oxalate in rosette-shaped crystals 25 to 30 μ in diameter; starch grains nearly spherical, 3 to 7 μ in diameter, single or compound.

84. **Stillingia.**—Light brown; sclerenchymatous fibers very long, thick-walled and swelling perceptibly in potassium hydrate solution; starch grains spherical or ellipsoidal, 15 to 30 μ in diameter; secretion cells containing oil, resin and a brown pigment; calcium-oxalate crystals rosette-shaped, 35 μ in diameter.

†† *Fibers with Relatively Thin Walls and not Strongly Lignified.*

85. **Euonymus.**—Light brown; bast fibers long, thin-walled, not lignified, the walls frequently modified to mucilage and possessing numerous small more or less oblique pores, and irregular ends; starch grains spherical, 4 to 10 μ in diameter; cork, thin-walled, white; secretion cells with yellowish or brownish masses; calcium-oxalate crystals rosette-shaped, 15 to 20 μ in diameter.

** NO RESIN OR TANNIN MASSES.

86. **Althæa.**—Light brown; sclerenchyma fibers long and not strongly lignified; crystals of calcium oxalate rosette-shaped, about 25 μ in diameter; starch grains somewhat ellipsoidal 10 to 20 μ in diameter.

2. SCLERENCHYMATOUS FIBERS WANTING.

* CONTAINING TANNIN.

† *With Oil-Secretion Reservoirs.*

87. **Caryophyllus.**—(See No. 135.)

88. **Pimenta.**—Dark brown; calcium-oxalate crystals rosette-shaped, occasionally in monoclinic prisms,

about 10 μ in diameter; starch grains somewhat spherical, about 10 μ in diameter, single or compound; stone cells nearly isodiametric, thin-walled, and with numerous simple pores and branched canals, contents colorless or reddish-brown; oil-secretion reservoirs with wine-colored contents; oil globules numerous; parenchymatous cells occasionally lignified, and with irregular reddish-brown tannin masses, which are colored greenish with ammonio-ferric sulphate solution.

†† *Oil-Secretion Reservoirs Wanting.*

89. **Galla (Aleppo).**—Dark yellow; crystals 10 μ in diameter; starch grains about 10 μ in diameter, single or sometimes in groups; stone cells; tannin; crystals of gallic acid.

90. **Geranium.**—Dark brown; starch grains somewhat ellipsoidal or ovoid, 10 to 15 μ in diameter; calcium-oxalate crystals rosette-shaped, 45 to 70 μ in diameter; ducts annular or scalariform; parenchyma with irregular tannin masses.

90a. **Rheum.**—(See No. 38).

** WITHOUT TANNIN.

91. **Belladonnæ Radix.**—Dark brown; ducts few, scalariform or with simple pores; sclerenchymatous fibers relatively few; starch grains numerous, somewhat spherical, 5 to 15 μ in diameter, single and two to three-compound.

β CRYSTALS IN MONOCLINIC PRISMS AND PYRAMIDS.

92. **Frangula.**—(See No. 41).

93. **Krameria.**—Light brown; sclerenchymatous fibers peculiarly bent, 0·3 to 0·5 mm. long and 15 μ thick; calcium oxalate in monoclinic prisms and pyramids about 0·1 mm. long; starch grains somewhat spherical, 20 to 30 μ in diameter, single or two to four-

compound. In Savanilla rhatany the sclerenchymatous fibers are 0·5 to 0·8 mm. long and 10 to 40 μ wide.

An alcoholic extract of Peruvian Rhatany gives with alcoholic lead acetate a reddish-brown precipitate and a light-brown filtrate. The tincture of Savanilla Rhatany gives a purplish precipitate and a colorless filtrate with this reagent.

93a. **Rhamnus Purshiana.**—(See No. 94.)

γ CRYSTAL FIBERS PRESENT.

1. SCLERENCHYMATOUS FIBERS STRONGLY LIGNIFIED.

* COLORED REDDISH WITH ALKALIES.

93b. **Frangula.**—(See No. 41).

94. **Rhamnus Purshiana.**—Light brown; bast fibers long, much thickened, lignified; stone cells very thick-walled, about 50 μ in diameter; crystal fibers containing monoclinic crystals of calcium oxalate; calcium oxalate also in rosette-shaped crystals or monoclinic prisms 5 to 20 μ in diameter; starch grains spherical, about 4 μ in diameter; parenchymatous cells with yellowish contents colored red with alkalies.

** NOT COLORED REDDISH WITH ALKALIES.

95. **Quercus Alba.**—(See No. 144).

96. **Prunus Virginiana.**—Light brown; bast fibers and stone cells much thickened and strongly lignified; crystal fibers containing monoclinic prisms and rosette-shaped crystals of calcium oxalate 20 to 30 μ in diameter; starch grains nearly spherical, 3 to 4 μ in diameter.

2. SCLERENCHYMATOUS FIBERS NOT STRONGLY LIGNIFIED.

97. **Calamus.**—Light brown; ducts spiral, scalariform or reticulate; sclerenchymatous fibers slightly lignified, with oblique simple pores; starch grains nearly spherical, 4 to 8 μ in diameter; crystal fibers containing monoclinic crystals of calcium oxalate; oil-secretion

cells with suberized walls; contents of parenchymatous cells colored ruby-red by a strong alcoholic solution of vanillin and hydrochloric acid. The powder of the peeled rhizome is less aromatic, and cells of epidermis and cork, and crystal fibers are wanting.

98. **Ulmus.**—Light brown; bast fibers thin-walled, non-lignified; crystal fibers containing monoclinic prisms of calcium oxalate 10 to 25 μ in diameter; starch grains spherical, 5 to 10 μ in diameter.

δ CALCIUM OXALATE IN RAPHIDES.

1. RAPHIDES NOT MORE THAN 10 μ LONG.

99. **Cinnamomum (Saigon).**—Dark brown; bast fibers much thickened; stone cells nearly isodiametric, more or less thickened, with numerous pores; calcium oxalate in raphides about 5 μ long; starch grains somewhat spherical, 7 to 15 μ in diameter, single or two to four-compound; parenchyma with irregular tannin masses; oil-secretion cells. Cassia Cinnamon has fewer cork cells and more sclerenchymatous cells and fibers. Ceylon Cinnamon has no cork cells and the stone cells are more elongated, irregular in outline and unevenly thickened.

100. **Sarsaparilla.**—Dark brown; sclerenchymatous fibers very thick-walled, somewhat lignified; ducts large, strongly lignified, scalariform, reticulate, and with simple pores; the walls of endodermis and hypodermis evenly thickened; starch grains somewhat spherical, 7 to 20 μ in diameter, single or two to four-compound; calcium oxalate in raphides 6 to 8 μ long. Distinguished from American Sarsaparilla, yielded by *Aralia nudicaulis,* in that the latter has rosette-shaped crystals of calcium oxalate 35 to 80 μ in diameter.

2. RAPHIDES 40 TO 45 μ LONG.

101. **Convallaria.**—Dark brown; calcium oxalate in raphides about 45 μ long; starch grains somewhat

spherical, 3 to 12 μ in diameter, single or two to four-compound; ducts spiral or scalariform; sclerenchymatous fibers long, thin-walled, with simple pores; endodermis with inner walls much thickened.

102. **Cypripedium.**—Brownish black; calcium oxalate in raphides about 40 μ long; starch grains somewhat spherical, 2 to 4 μ in diameter, single or compound; ducts spiral, scalariform or with simple pores; sclerenchymatous fibers long, thin walled; parenchyma thick-walled, with numerous simple pores.

103. **Veratrum Viride.**—(See No. 47).

ε CALCIUM OXALATE IN CRYPTOCRYSTALLINE CRYSTALS.

103a. **Belladonnæ Radix.**—(See No. 91.)

104. **Cinchona.**—(See No. 115.)

b. Calcium-Oxalate Crystals Wanting.

a. WITH NON-SECRETION HAIRS.

105. **Strophanthus.** — Dark brown; epidermal cells modified to long one-celled non-lignified hairs, containing, in *S. Kombe,* colorless or yellowish-green granules and in *S. hispidus,* dark-brown granules; parenchyma with fixed oil and aleurone grains; starch grains ellipsoidal, 4 μ in diameter.

β NON-SECRETION HAIRS WANTING.

1. SCLERENCHYMATOUS FIBERS PRESENT.

* DUCTS NUMEROUS.

† *Starch Grains 2 to 5 μ in Diameter.*

106. **Cimicifuga.**—Brownish black; ducts large, scalariform or with bordered pores; sclerenchymatous fibers numerous; starch grains nearly spherical, 3 to 5 μ in diameter; cells of periderm thick-walled and with reddish-brown contents.

107. **Cypripedium.**—(See No. 102.)

108. **Leptandra.**—Dark brown; ducts scalariform or

with simple pores; sclerenchymatous fibers narrow, thick-walled, with numerous simple pores; starch grains nearly spherical, 2 to 4 μ in diameter; parenchymatous cells nearly isodiametric or elongated, containing starch grains and a brownish-black pigment.

109. **Spigelia.**—Brownish black; ducts few, lignified, spiral or with simple pores; sclerenchymatous fibers long, narrow, lignified, with simple, oblique pores; starch grains spherical, about 4 μ in diameter.

†† *Starch Grains 5 to 15 or 20 μ in Diameter.*

110. **Apocynum.** — Dark brown; sclerenchymatous fibers numerous; fragments of laticiferous vessels yellowish; starch grains somewhat spherical, 7 to 15 μ in diameter. In *Apocynum androsæmifolium* small groups of stone cells occur.

111. **Convallaria.**—(See No. 101.)

112. **Sarsaparilla.**—(See No. 100.)

113. **Sumbul.**—Dark brown; sclerenchymatous fibers numerous, narrow and lignified; ducts short, lignified, scalariform, or with simple or bordered pores; oil and resin-secretion reservoirs; starch grains nearly spherical, 4 to 15 μ in diameter.

114. **Valeriana.**—Brownish black; ducts strongly lignified, scalariform or with simple pores; sclerenchymatous fibers thin-walled, more or less lignified, with numerous simple pores; starch grains nearly spherical, 7 to 15 μ in diameter; stone cells nearly isodiametric, with very thick walls and numerous simple pores.

** DUCTS FEW OR NONE.

115. **Cinchona.**—Light brown; bast fibers spindle-shaped, thick-walled, strongly lignified, with numerous simple pores; starch grains nearly spherical, 4 to 12 μ in diameter; parenchymatous cells with reddish-brown tannin masses.

116. **Cinnamomum.**—(See No. 99.)

117. **Coffee.**—Brownish; characteristic fragments of seed-coat made up of parenchyma and spindle-shaped stone cells 175 to 200 μ long and 35 μ wide; composed mostly of the cells of endosperm, these having brownish-colored porous walls, 10 μ thick, and containing oil, aleurone and starch. The ground coffee of the market is either made from the true coffee seed or is an artificial mixture of cereals, chicory, etc.

118. **Sassafras.**— Light brown; bast fibers thick-walled, lignified, usually single or not more than two or three together; starch grains 7 to 20 μ in diameter, single or two to three-compound; parenchymatous cells with irregular masses of tannin; oil globules numerous. The stem bark contains groups of bast fibers and stone cells, and the parenchymatous cells contain chloroplastids.

2. SCLERENCHYMATOUS FIBERS WANTING.

* STONE CELLS PRESENT.

† *Giving Tannin Reaction with Ferric Salts.*

119. **Cacao.**—Reddish brown; consisting chiefly of protein grains and oil; starch grains 4 to 8 μ in diameter; fragments with brownish contents (cacao red); fat crystals in little prisms or needles; few fragments of seed-coat consisting of hexagonal epidermal cells, a peculiar mucilage layer of small tabular cells and a layer of nearly isodiametric stone cells (10 x 10 μ), the walls of which are 4 μ thick.

120. **Guarana.** — Dark brown; parenchyma thin-walled, containing nearly spherical, more or less altered starch grains 10 μ in diameter; sclerenchymatous cells nearly isodiametric, non-lignified; sclerenchymatous fibers few, narrow; ducts few, narrow, annular or scalariform.

121. **Piper.**—Dark brown; stone cells nearly isodiametric, uniformly thickened or with only three walls thickened, the contents yellowish-brown tannin masses, giving a blue reaction with ferric ammonium sulphate solution; starch grains spherical, 1 to 2 μ in diameter; parenchyma with remains of chromoplastids and reddish-brown tannin masses; oil-secretion cells with suberized walls; oil globules numerous; ash not more than 6 per cent.

In the powder of the endocarp of Olive Fruit [*Olea Europæa* (Fam. Oleaceæ)], the lumen of the stone cells is filled with air.

122. **Colchici Semen.**—Light or dark brown; sclerenchymatous cells with pigment soluble in potassium hydrate solution, and reacting with iron salts somewhat like tannin; cells of endosperm thick-walled, with simple pores and few oil globules; parenchymatous cells of strophiole thin-walled, and with numerous nearly spherical starch grains 7 to 15 μ in diameter.

†† *Not Becoming Blue or Green with Ferric Salts.*

123. **Aconitum.**—Dark brown; ducts few, spiral, scalariform, reticulate, or with simple pores; stone cells nearly isodiametric, variously thickened, associated with thick-walled parenchyma, the latter swelling in water; starch grains somewhat spherical, 4 to 12 μ in diameter, single or two to four-compound.

124. **Physostigma.**—Brownish black; taste starchy; stone cells nearly isodiametric or elongated, the contents reddened by alkalies; starch grains ellipsoidal, about 25 to 40 μ in diameter; oil globules numerous.

** STONE CELLS WANTING.

125. **Aconitum.**—Stone cells few. (See No. 123.)

126. **Colchici Cormis.**—Light or dark brown; starch grains irregularly spherical or ovoid, 7 to 20 μ in diam-

eter, single or two to four-compound ; ducts few, spiral or scalariform.

127. **Guarana.**—(See No. 120.)

128. **Myristica.**—Light brown; perisperm cells with reddish contents; starch grains somewhat spherical, 5 to 7 μ in diameter, generally in groups; globules of fixed oil numerous. Starch grains of mace are colored red with iodine.

129. **Opium.**—(See No. 157.)

130. **Podophyllum.**—Light brown; starch grains somewhat spherical, 5 to 12 μ in diameter, single or two to six-compound; ducts few, scalariform, spiral, reticulate, or with simple pores.

B. STARCH GRAINS FEW OR NONE.

a. Containing Calcium Oxalate.

a IN ROSETTE-SHAPED CRYSTALS.

1. SMALL CRYSTALS IN ALEURONE GRAINS.

131. **Anisum.**—(See No. 54.)

132. **Carum.**—Dark brown; calcium-oxalate crystals rosette-shaped, 0·5 to 1 μ in diameter in aleurone grains; fragments of light-yellow vittæ, together with nearly isodiametric or polygonal yellowish-brown inner epidermal cells of pericarp; sclerenchymatous fibers few, thick-walled, slightly lignified, with numerous simple pores; oil globules numerous.

133. **Coriandrum.**—Light brown; calcium-oxalate crystals rosette-shaped, 3 to 7 μ in diameter in aleurone grains; fragments of light-yellow vittæ and with long narrow, yellowish, inner epidermal cells; sclerenchymatous cells irregularly curved, yellowish, thick-walled, lignified and with numerous simple pores; oil globules numerous.

134. **Fœniculum.**—(See No. 56.)

2. CRYSTALS NOT LESS THAN 10 μ IN DIAMETER.

* POLLEN GRAINS NUMEROUS.

135. **Caryophyllus.**—Light brown; pollen grains tetrahedral, somewhat spherical, with three pores, about 15 μ in diameter; calcium oxalate in rosette-shaped crystals 10 to 15 μ in diameter, occasionally in crystal fibers; sclerenchymatous fibers spindle-shaped, thick-walled, strongly lignified and with simple oblique pores; ducts spiral, thick-walled; oil globules numerous. The powder of clove stems is less aromatic and contains numerous nearly isodiametric and irregular thick-walled stone cells with numerous canals and also scalariform and reticulate ducts. The powder of the fruit of cloves (known commercially as the mother of cloves) contains numerous single, oblong and irregular starch grains with excentral point of origin of growth.

136. **Insect Powder.**—(See No. 5.)

** POLLEN GRAINS FEW.

† *Ducts Present.*

137. **Cusso.**—Light brown; calcium-oxalate crystals rosette-shaped, about 20 μ in diameter; non-secretion hairs one-celled, curved, thick-walled, 0·2 to 0·5 mm. long; secretion hairs with two or three-celled stalk, glandular head unicellular or consisting of one or two pairs of cells; ducts spiral, scalariform, or with bordered pores; sclerenchymatous fibers long, thick-walled, strongly lignified, with numerous simple oblique pores; parenchyma of pith more or less lignified and with simple pores; pollen grains few, somewhat ellipsoidal, 25 to 40 μ in diameter, with three pores.

†† *Ducts Wanting.*

138. **Viburnum Opulus.**—(See No. 141.)

139. **Viburnum Prunifolium.**—Dark brown; calcium oxalate in rosette-shaped crystals and few monoclinic prisms 15 to 35 μ in diameter; crystal fibers with rosette-shaped crystals and occasional monoclinic prisms of calcium oxalate; stone cells large, numerous, irregular, thick-walled and with a few canals; bast fibers comparatively few, lignified.

β CALCIUM OXALATE IN MONOCLINIC PRISMS.

1. NUMEROUS SEEDS.

140. **Vanilla.**—Blackish brown; calcium oxalate in monoclinic prisms 7 to 35 μ in diameter or in raphides about 0·4 mm. long; unicellular secretion hairs with rounded apex and containing oily globules; sclerenchymatous fibers more or less thick-walled; the walls strongly lignified and with numerous simple pores; seeds with small thick-walled stone cells.

The powder of Mexican Vanilla has parenchymatous cells with reticulate thickenings. The powder of Tonka Bean contains numerous starch grains, which are nearly spherical, about 7 μ in diameter.

2. SEEDS WANTING.

141. **Viburnum Opulus.**—Light brown; calcium oxalate in monoclinic prisms, or few rosette-shaped crystals 15 to 30 μ in diameter; crystal fibers with monoclinic prisms of calcium oxalate; stone cells few, relatively thick-walled; bast fibers numerous, lignified.

142. **Viburnum Prunifolium.**—(See 139.)

143. **Xanthoxylum.**—Dark brown; calcium oxalate in monoclinic prisms 10 to 25 μ in diameter; starch grains nearly spherical, 4 to 10 μ in diameter; oil-secretion cells colorless; cork cells strongly lignified; bast fibers few, thick-walled, slightly lignified, swelling perceptibly in chloral.

In Southern Prickly Ash occur groups of large, more

or less lignified sclerenchymatous cells; the lignified cork cells are more numerous.

γ CALCIUM OXALATE IN CRYSTAL FIBERS.

144. **Quercus Alba.**—Light brown; bast fibers long, thick-walled, lignified; crystal fibers containing rosette-shaped crystals or monoclinic prisms of calcium oxalate about 10 to 20 μ in diameter; stone cells thick-walled, with numerous lamellæ and simple pores; parenchyma with irregular yellowish-brown tannin masses.

b. Calcium Oxalate Wanting.

a CONTAINING POLLEN GRAINS.

145. **Arnicæ Flores.**—(See No. 63).

146. **Crocus.**—(See No. 65).

147. **Santonica.**—Light brown; pollen grains nearly spherical, nearly smooth, three-pored, 15 to 20 μ in diameter; secretion hairs of two kinds, either with one or two short cells or with two to three pairs of cells. If a few c.c. of an alcoholic (95 per cent.) extract be heated with a few drops of potassium hydrate solution, a reddish color is produced.

β POLLEN GRAINS WANTING.

1. STONE CELLS NUMEROUS.

149. **Cubeba.**—Light brown; stone cells single or in isolated groups, nearly isodiametric, thick-walled, with numerous simple pores, and colorless or light-yellow contents; sclerenchymatous fibers few, short, thick-walled, strongly lignified; parenchymatous cells with reddish-brown tannin masses; oil-secretion cells with suberized walls; oil globules numerous; fragments of powder becoming wine-colored with sulphuric acid.

2. STONE CELLS WANTING.

150. **Gentiana.**—Light brown; ducts few, scalariform or reticulate; intermediate fibers non-lignified and

with irregular, simple, oblique pores; few globules of fixed oil.

151. **Opium.**—(See No. 157).

152. **Pyrethrum.**—Dark brown; parenchymatous cells with irregular crystalloidal masses of inulin; periderm with nearly isodiametric stone cells, the contents of which are yellowish brown; ducts reticulate, narrow; sclerenchymatous fibers few; secretion reservoirs with oil and resin.

The root of *Anacyclus officinarum* contains tannin, and an aqueous extract gives a precipitate with ammonio-ferric-alum solution.

153. **Taraxacum.**—Light brown; parenchyma containing irregular crystalloidal masses of inulin; laticiferous vessels yellowish brown; ducts reticulate; intermediate fibers non-lignified, with irregular simple and oblique pores.

154. **Triticum.**—Light brown; ducts lignified, with spiral or annular thickenings or simple pores; sclerenchymatous fibers long, thick-walled, strongly lignified; endodermal cells with inner walls thickened and slightly lignified; parenchyma with irregular masses of a soluble carbohydrate.

II. WITHOUT FIBROVASCULAR TISSUE.

A. WITH CELLULAR TISSUES.

155. **Ustilago.** — Grayish-brown, nearly spherical spores (7 x 7 μ); little or no foreign substances. Spores of *Coprinus comatus*, blackish and ellipsoidal (10 x 5 μ). Spores of *Agaricus campestris* more brownish than those of corn smut, ovoid and about 5 x 7 μ.

156. **Ergota.**—Oil globules; red or violet coloration in chloral and sulphuric acid; odor peculiar.

157. **Opium.**—Brownish; in glycerin mounts consisting of grayish-brown, irregular granular masses

(35 to 40 μ in diameter); little or no starch; cells of epidermis of capsule 40 μ in diameter; taste bitter; sparingly soluble in water or potassium hydrate solution. The Smyrna opium has the largest number of epidermal cells of capsule, the Indian few or none and the Persian very few. The Persian always has an appreciable amount of starch.

B. WITHOUT CELLULAR TISSUES.

a. Possessing Oil.

158. **Asafetida.**—In a glycerin mount the powder shows irregular grayish (or gray streaked with brown) masses; these are opaque and become milky white on the edge from the presence of oil. The stony asafetida is pulverulent and contains less oil.

159. **Myrrha.**—In glycerin mount the powder appears in yellowish or yellowish-brown irregular fragments made up of a grayish matrix containing yellowish or yellowish-brown oil globules.

b. Without Oil.

a REMAIN OPAQUE (NOT AFFECTED) IN GLYCERIN.

160. **Aloes (Socotrine).**—Slightly affected. (See No. 166.)

161. **Benzoinum.**—Irregular, colorless and wine-colored fragments; some rosette-shaped groups and collections of small tetragonal crystals. Upon covering a fragment on a slide with a watch crystal and cautiously heating, crystals of benzoic acid are sublimed on the watch crystal.

162. **Elaterinum.**—Grayish and grayish brown, more or less opaque, irregular fragments; upon heating a fragment with phenol, and when cool, adding sulphuric acid, a deep-red coloration is produced. Potassium hydrate has no action on elaterin.

163. **Goa Powder.**—Small, wine-colored, somewhat translucent, irregular angular fragments; bright reddish with potassium hydrate; few ducts and libriform cells with bordered pores.

164. **Lactucarium.**—Grayish brown and dark brown, irregular and rather angular masses; with alkalies they become reddish brown and then a dirty brown; with sulphuric acid it is but slightly affected.

β BECOME MORE OR LESS TRANSPARENT IN GLYCERIN.

165. **Aloes (Curacao).**—In a glycerin mount the particles become clear and behave like Cape aloes, but generally, numerous acicular or large prismatic crystals remain, or separate in the clear yellow space where the fragment of aloes was originally.

166. **Aloes (Socotrine).**—In a glycerin mount the fragments are not very perceptibly affected. At the most there is but a faint yellowish color around the grayish or grayish-brown masses. In old Socotrine aloes the gray masses look like rosette crystals.

167. **Catechu.**—Large opaque, dark brownish-red masses which gradually become transparent on the edge and dissolve with a sherry-wine color; fragments of sclerenchyma are also present.

168. **Kino.**—Blackish-brown fragments become clearer and of a deeper red (port-wine) color as compared to catechu.

POWDERS OF A REDDISH COLOR.

This group includes those powdered drugs which are of a pinkish, reddish, brownish-red (brown madder) and rose-color.

I. CONTAINING STARCH.

169. **Quillaja.**—Pinkish; very sternutatory; calcium oxalate in monoclinic pyramids from 35 to 200 μ long;

bast fibers numerous, thick-walled, strongly lignified; crystal fibers containing monoclinic prisms of calcium oxalate; stone cells more or less thick-walled and with simple oblique pores; starch grains nearly spherical, 3 to 10 μ in diameter.

170. **Sanguinaria.**—Reddish; starch grains spherical, 4 to 8 μ in diameter; reddish secretion cells; ducts few, reticulate.

II. WITHOUT STARCH.

A. STONE CELLS PRESENT.

171. **Capsicum.**—Brownish red; stone cells of two kinds, either nearly isodiametric, uniformly thickened and with middle lamella slightly lignified, or somewhat elongated on surface view, convolutely thickened on the inner and side walls and strongly lignified; starch grains somewhat spherical, about 3 to 7 μ in diameter, single or compound; secretion hairs with one- to three-celled stalk and multicellular glandular head; collenchymatous cells with suberized walls; parenchymatous cells with yellowish-red oil globules and irregular masses of chromoplastids.

172. **Rhus Glabra.**—Brownish red; non-secretion hairs unicellular, narrow, thick-walled, filled with air, or multicellular, cylindrical, ellipsoidal or spatulate and with a wine-colored pigment; secretion hairs with one-celled stalk and multicellular globular or ellipsoidal head, with yellowish-brown contents; stone cells about 20 μ in diameter, thick-walled, strongly lignified, with numerous canals; oil globules numerous.

B. STONE CELLS WANTING.

a. With Wood Fibers.

173. **Hæmatoxylon.** — Reddish; ducts with simple pores; schlerenchymatous fibers long, thin-walled;

crystal fibers with monoclinic crystals of calcium oxalate.

174. **Santalum Rubrum.**—Reddish; ducts with bordered pores; sclerenchymatous fibers long, thin-walled; crystal fibers with monoclinic crystals of calcium oxalate.

b. Wood Fibers Wanting.

175. **Crocus.**—(See No. 65).

176. **Kino.**—(See No. 168).

177. **Lupulinum.**—Reddish brown; large characteristic secretion hairs about 20 μ in diameter. In fresh Lupulin there are more light yellow-secretion hairs than in old. In the latter there are browner or grayish-brown resinous masses replacing the light-yellow oil. The amount of Humulus fragments should not be too large in Lupulin of good quality.

178. **Opium.**—(See No. 157).

179. **Rosa Gallica.**—Rose-colored; epidermis with acute papillæ; pollen grains few, somewhat spherical, 30 μ in diameter.

POWDERS OF A WHITISH APPEARANCE.

This group includes all those powders which are light in color, and comprises chiefly the commercial starches, cereals, gums and some of the inorganic substances which are occasionally used as adulterants.

I. PLANT TISSUES OR CELL-CONTENTS RECOGNIZABLE.

A. CONTAINING STARCH.

a. Only Unaltered Starch Grains Present.

Grains characteristic for each; completely soluble in glycerin on heating, and precipitated on the addition of alcohol, the precipitate being soluble in water.

180. **Arrow Root Starch** (Bermuda).

181. **Potato Starch.**

182. **Corn Starch.**

183. **Rice Starch.**

184. **Wheat Starch.**—Does not agglutinate on mixing with water, distinction from wheat flour.

b. Altered and Unaltered Starch Grains Present.

185. **Dextrin.**—Sticky mass with water; few unaltered starch grains also present.

c. Plant Tissues in Addition to Starch Grains.

The former remain upon treatment with hot glycerin.

α. DO NOT READILY DISSOLVE OR SWELL IN COLD WATER.

186. **Corn Meal.**—More starch and oil and little hull, as compared to cornbran.

187. **Corn Bran.**—Less starch and oil and more hull, as compared to cornmeal.

188. **Wheat Flour.**—Agglutinates with water, distinction from wheat starch; little tissue of wheat grain.

189. **Wheat Middlings.**—Starch and numerous fragments of tissues of wheat.

190. **Nux Vomica.**—(See No. 195.)

191. **Orris Root.**—Characteristic starch grains 15 to 30 μ in diameter; scalariform ducts 25 μ in diameter; no cork.

191a. **Quillaja.**—(See No. 169).

β. SOLUBLE IN OR SWELLING IN COLD WATER TO FORM A STICKY MASS.

192. **Acacia (White).**—Soon affected by water; few plant tissues present.

193. **Tragacantha.**—Slowly affected by water; frag-

ments of ducts and parenchyma; starch grains more or less spherical and from 2 to 10 μ in diameter.

B. WITHOUT STARCH.

a. Calcium Oxalate Present.

194. **Scilla.**—Raphides; also isolated fragments of fibrovascular tissue.

b. Calcium Oxalate Wanting.

195. **Nux Vomica.**—Grayish white; odor slight; taste intensely and persistently bitter; epidermal cells modified to strongly lignified hairs; endosperm cells containing a fixed oil and aleurone grains, thick-walled, finely porous and giving a blue or violet color with potassium bichromate and sulphuric acid.

Small, nearly spherical starch grains occur in the tissues of adhering fruit pulp.

II. ABSENCE OF PLANT TISSUES.

A. SOLUBLE IN WATER.

196 **Saccharum.**—Characteristic crystals; soluble also in mounts of glycerin and glycerin + chloral; taste sweet.

B. INSOLUBLE IN WATER.

a. Soluble in Alcohol.

197. **Camphora.**—Liquefies in mounts of glycerin and chloral; glycerin mounts show irregular masses.

b. Insoluble in Alcohol.

α REDDISH COLOR WITH SULPHURIC ACID AFTER SOME TIME.

198. **Saccharum Lactis.**.—Small and large irregular-shaped crystals insoluble in mounts of glycerin or glycerin + chloral.

β NO COLOR REACTION WITH SULPHURIC ACID.

1. SOAPY FEEL.

199. **Talc (Magnesium Silicate).**— Rather long irregular lustrous and broken crystals.

2. SOLUBLE IN ACETIC ACID.

* WITH EFFERVESCENCE.

200. **Calcii Carbonas Præcipitatus.** — By adding hot solution of ammonium oxalate to acetic-acid solution on slide, crystals of calcium oxalate are obtained. Mounts in glycerin show rosette or cubical crystals of a rather uniform size.

201. **Creta Præparata.**—Same treatment as above, but calcium-oxalate crystals are triangular and cubical and not of uniform size.

202. **Barium Carbonate.**—Add sulphuric acid, and in glycerin mount the barium sulphate precipitate is bacteria-like.

** SOLUBLE IN ACETIC ACID WITHOUT EFFERVESCENCE.

203. **Magnesia Ponderosa.**—In glycerin mount alone small rounded masses are observed frequently grouped together; if a few milligrammes be dissolved in citric acid on a slide or watch crystal, then a few drops (excess) of ammonium hydrate and sodium phosphate solution added and stirred vigorously with a glass rod, triangular or tetragonal crystals are formed.

204. **Magnesia.**—In a glycerin mount the masses have the appearance of heavy magnesia, but are larger and more transparent. On treatment with citric acid, ammonium hydrate and sodium phosphate, the crystals of ammonium-magnesium phosphate in glycerin mount are large, star-shaped, and look like snow-crystals.

3. INSOLUBLE IN ACETIC ACID.

* SOLUBLE IN NITRIC ACID.

If necessary, in deciding on any of the next four, they are to be fused with potassium carbonate or sodium carbonate, and a regular qualitative chemical separation effected.

205. **Calcii Phosphas Præcipitatus.**—In glycerin mount alone small tetragonal and cubical crystals are observed. If to a few milligrammes of the powder on a slide we add a few drops of nitric acid, and then ammonium molybdate solution, stirring well with a glass rod, small yellow diamond-shaped crystals are observed, which are permanent in glycerin mounts.

206. **Calcii Sulphas.**—In glycerin mount alone needle-shaped crystals, or long crystals in masses which look like a group of sclerenchyma fibers, are observed; flame test with platinum wire = bright reddish yellow.

207. **Barium Sulphate.**—In glycerin mount alone irregular-shaped crystals varying from small to large are observed; flame test = green.

208. **Terra Alba.**—This is aluminum silicate and magnesia (3 : 5) and occurs in irregular masses.

INDEX OF POWDERED DRUGS.

PART III.

REAGENTS.

The reagents that have been recommended for microscopical work are quite numerous, and while nearly all of them may have more or less special merit, the number of reagents actually required in practice is fortunately quite small.

It is important that the student recognize the necessity for a thorough understanding of the structure of the material under examination rather than place too much dependence upon the effects produced by reagents; in other words, the study of structure should precede the use of reagents, particularly stains, when it will often be found that the latter can be dispensed with entirely.

The chemicals that are employed in microscopical work, either as reagents or for other purposes, may be classified as follows: (1) Preservatives, (2) Fixing and Killing Agents, (3) Hardening and Dehydrating Agents, (4) Clearing Agents, (5) Stains and (6) Special Reagents.

Preservatives are substances used to preserve material which is to be examined. The most important of these are alcohol (from 40 to 95 per cent.) and formalin [2 to 6 per cent, in either aqueous or alcoholic (60 per cent. alcohol) solution], the latter of which is considered advantageous in the preservation of specimens containing coloring substances, as leaves, flowers, etc. Almost any antiseptic of the proper strength may be used as a preservative.

Fixing and Killing Agents are more especially employed in the study of the organized cell-contents, where by their use the life-processes of the cell are brought to a sudden termination, the object being to fix the contents in a condition approaching as nearly as possible the normal living state. In order to carry out this operation successfully, the living specimen must be placed in the fixing or killing agent as soon as collected, and if the specimen is large it should be cut into small pieces. The following are some of the common fixing agents: Chromic acid in 0·5 to 1 per cent. aqueous solution; osmic acid in 1 to 2 per cent. aqueous solution; Flemming's Mixture, which is an aqueous solution of chromic acid (0·25 per cent.) containing 0·1 per cent. of osmic acid and 0·1 per cent. of acetic acid; picric acid in concentrated aqueous or alcoholic solution; picric-sulphuric acid, a concentrated aqueous solution of picric acid containing 2 per cent. by volume of sulphuric acid; and mercuric chloride (corrosive sublimate) used in 0·1 to 1 per cent. aqueous or alcoholic solution.

Hardening or Dehydrating Agents are those substances which are employed for the purpose of hardening the specimen so as to facilitate sectioning and for removing the water, which would interfere with its examination. Alcohol is to be regarded as the principal hardening or dehydrating agent, and considerable care is necessary in its use; the specimen is treated successively with alcoholic solutions of gradually increasing strength, beginning with a 35 per cent. solution, in which the specimen is kept for twenty-four hours; then it is placed in 50 per cent. alcohol for from six to twenty-four hours, and then in 70 per cent. alcohol in which it may be kept until ready for use. In order to avoid shrinking of the material at this stage, it may

be kept in a solution of alcohol and glycerin, or oil of bergamot or a mixture of xylol and paraffin. When the material is to be examined it should be removed to 85 per cent. alcohol for from six to twenty-four hours, then to 95 per cent. alcohol and absolute alcohol successively for the same length of time. Of the other dehydrating agents the most important are anhydrous glycerin, pure carbolic acid, and anhydrous sulphuric acid, the latter being used in a desiccator and not applied directly to the specimen.

Clearing Agents.—Most dehydrating agents are also clearing agents because of the fact that the air and water in the specimen are replaced by a medium having greater refractive properties. Some clearing agents act chemically on the tissues and cell-contents. Among the clearing agents most frequently employed are: Chloral in saturated aqueous solution, and chloral-glycerin solution, a solution of equal parts of glycerin and water saturated with chloral. Essential oils, as clove, turpentine, cedar, marjoram, etc., are also useful for this purpose, particularly when the specimen is to be mounted in Canada balsam.

Staining Agents are those that produce more or less definitely colored compounds with the cell-contents or walls. They may be divided into two classes: (1) the Aniline Dyes and (2) Non-aniline Stains.

The aniline stains may be used in aqueous solutions, weak alcoholic solutions or strong alcoholic solutions, in which from 1 to 3 per cent. of the dye is dissolved. The following are the aniline stains most frequently employed: Aniline blue, Bismarck brown, fuchsin, gentian violet, methylene blue, methyl violet and safranin. In addition to these, aniline hydrochloride or sulphate is used in what is known as "Wiesner's Reagent," which is a 25 per cent. solution of alcohol containing 5 per

cent. of either of these salts, a drop of either hydrochloric or sulphuric acid being used with a drop of the solution, according as the hydrochloride or sulphate has been used.

The non-aniline stains give, as a rule, more reliable and constant results than the aniline stains. They include the following:

Beale's Carmine Solution, which is made as follows: Mix 0·6 gramme carmine with 3·75 grammes ammonia water (10 per cent.); heat on a water-bath for several minutes; then add 60 grammes of glycerin, 60 grammes of water and 15 grammes of alcohol, and filter.

Grenacher's Borax-Carmine Solution.—Dissolve 2 to 3 grammes of carmine and 4 grammes of borax in 93 c.c. of water and then add 100 c.c. of alcohol (70 per cent.); shake and filter. When this stain is employed the sections are freed from an excess by the use of alcoholic solutions of borax or oxalic acid.

Hoyer's Carmine Solution is an aqueous solution of an ammonium compound of carmine, to which 0·5 per cent. of ammonium carbonate has been added. An excess of the stain is removed from sections by the use of either alcohol alone or alcohol containing a small amount of acid.

Acetic Carmine Solution is made by adding acetic acid to Hoyer's carmine solution until the solution becomes of a brick-red color. For washing the sections a solution of glycerin containing 0·5 per cent. of hydrochloric acid or 1 per cent. of formic acid is employed.

Hoyer's Picro-Carmine Solution is made by dissolving carmine in a concentrated solution of neutral ammonium picrate. A solution of carmine and picric acid is known as "Picro-Carmine Solution."

P. Mayer's Carmine Solution.—Four grammes of carmine are mixed with 15 c.c. of water and 30 c.c. of hydrochloric acid, and the mixture heated on a water-bath; to this 95 c.c. of alcohol are added and the solution boiled, neutralized with ammonia water (10 per cent.), and filtered when cool.

Chlor-zinc-iodide Solution, or Schulze's Cellulose Reagent, consists of anhydrous zinc chloride, 25 grammes; potassium iodide, 8 grammes; and water 8·5 grammes, to which as much iodine is added as it will dissolve.

Bohmer's Hæmatoxylin Solution is prepared by mixing the two following solutions and filtering after standing for several days: (*a*) one part of a 3·5 per cent. alcoholic (95 per cent.) solution of hæmatoxylin and (*b*) three parts of a 0·4 per cent. aqueous solution of potassium alum.

Delafield's Hæmatoxylin Solution, which is also incorrectly called "Grenacher's Hæmatoxylin Solution," is made by mixing the following solutions: (*a*) Hæmatoxylin 4 grammes, alcohol 25 c.c. and (*b*) 400 c.c. of a saturated aqueous solution of ammonia alum; this solution is exposed to the light for three or four days, filtered, and then 100 c.c. each of glycerin and methyl alcohol are added, the solution allowed to stand for several days and finally filtered. An excess of the stain is removed from the sections by subsequent washing either with a 2 per cent. alum solution or an acidified alcoholic solution.

Iodine and Potassium-Iodide Solution consists of iodine, 13 grammes; potassium iodide, 20 grammes; water, 100 c.c.

Iodine Water is prepared by adding as much iodine to distilled and sterilized water as it will dissolve (about 1 : 5,000).

Chloral-Iodine Solution consists of a saturated aqueous solution of chloral, to which as much iodine is added as it will take up.

Phloroglucin Solution, also known as "Wiesner's Reagent," is a 0·5 to 2 per cent. alcoholic solution of phloroglucin, which is used in conjunction with hydrochloric acid.

Iron Solutions are aqueous or alcoholic solutions containing 5 to 20 per cent. of ferric acetate or ferric chloride. The name "Mœller's Reagent" is given to a solution of anhydrous ferric chloride in anhydrous ether.

Copper-Acetate Solution is a 7 per cent. aqueous solution of cupric acetate.

Double Staining, or the use of two stains in the examination of a specimen, furnishes not only a means of beautifying the specimen, but also has a certain diagnostic value. The following are some of the combinations used: (*a*) aqueous solutions of carmine in connection with alcoholic solutions of iodine green; (*b*) alcoholic solutions of hæmatoxylin and safranin; (*c*) solutions of eosin and methylene blue; (*d*) solutions of fuchsin and methylene blue; (*e*) solutions of gentian violet and Bismarck brown.

Special Reagents comprise all those substances which are employed in the morphological study of the cells, and include solutions of the alkalies (0·1 to 6 per cent.), solutions of the mineral acids, which may be weak or concentrated, and solutions of organic acids, as acetic and citric.

Schulze's Macerating Solution is prepared by adding crystals of potassium chlorate from time to time to a warm concentrated nitric acid. It is employed in the isolation of lignified cells.

MOUNTING OF SPECIMENS.

Microscopic preparations or mounts are of two kinds: they may serve a temporary purpose only or they may be prepared so as to serve for future study, the latter being known as **permanent mounts.**

In taking up the study of a specimen it should first be mounted in water and examined; then the water may be replaced by a weak aqueous solution of glycerin (5 to 10 per cent.) and the specimen examined again. After this preliminary examination other agents and reagents may be employed. Specimens mounted in glycerin will keep for several days and even months. Generally speaking, the only effect which the glycerin has on the tissues or contents is that of swelling them, which is obviated, to a greater or less extent, however, if the glycerin is washed out when an examination is made.

In addition to the methods involving the use of glycerin, there are two ways of making permanent mounts, depending upon the employment either of Canada balsam or glycerin jelly as the mounting medium. The method involving the use of the latter is the simpler, and leaves the specimen in such a condition that a re-examination with reagents can be made if desirable. **Glycerin-jelly mounts** are made as follows: Specimens which have been previously treated are transferred to glycerin and allowed to remain for several hours, the excess of glycerin removed, and the specimen transferred to a warm slide on which a drop of glycerin jelly[1] has been placed. The preparation is

[1] Kaiser's Glycerin Jelly.—Soak 7 grammes of gelatin in 42 grammes of water for two hours; dissolve 1 gramme of carbolic acid in 49 grammes of glycerin; mix the two solutions; heat on a water-bath, with occasional stirring for fifteen minutes, and finally filter through glass wool. The jelly is warmed slightly to liquefy it before using.

warmed slightly to remove air-bubbles, and a warm coverglass applied, care being taken to prevent the formation of air-bubbles. Evaporation of the glycerin jelly is prevented by the use of shellac cements, asphalt varnish or candlewax.

The following method may be used for the preparation of **Canada balsam mounts**: The specimen is cleared, dehydrated by the use of alcohol and then placed in chloroform or benzol. The clearing of the specimen is materially assisted by placing it in oil of cloves or turpentine prior to mounting it. A drop of Canada balsam solution (1 part of balsam to 3 parts of chloroform or benzol) is placed on a slide and the specimen mounted. When the preparation is nearly dry, scrape off the excess of balsam and clean the slide and coverglass with chloroform or benzol, and ring with cement.

PART IV.

ILLUSTRATIONS.

The illustrations herewith presented are to be considered as an essential feature of this book, and are intended as an aid both in the study of plant morphology (Part I) and in the study of the descriptions under crude drugs and of powdered drugs (Part II).

LIST OF PLATES.

Plate I.

ORGANIZED CELL-CONTENTS.

Fig. 1.—Surface section of the epidermis of the onion showing the protoplasm lining the cell-walls and the nuclei imbedded in it.

Fig. 2.—Transverse section of green fruit of *Capsicum annuum* showing protoplasm, nuclei and chloroplastids.

Fig. 3.—A chloroplastid of a species of *Funaria* showing green spherical bodies, colorless bodies, etc. (see text, p. 12).

Fig. 4.—Transverse section of ripe fruit of *Capsicum annuum* showing protoplasm, nuclei and chromoplastids.

Fig. 5 —Transverse section near the periphery of a tuber of *Phajus grandiflorus* showing a cell with protoplasm and starch grains, the latter with adhering chloroplastids.

Fig. 6.—Transverse section of petal of *Viola tricolor* showing epidermal cells with dissolved cell-sap.

Fig. 7.—Isolated chromoplastids of the carrot.

PLATE I.

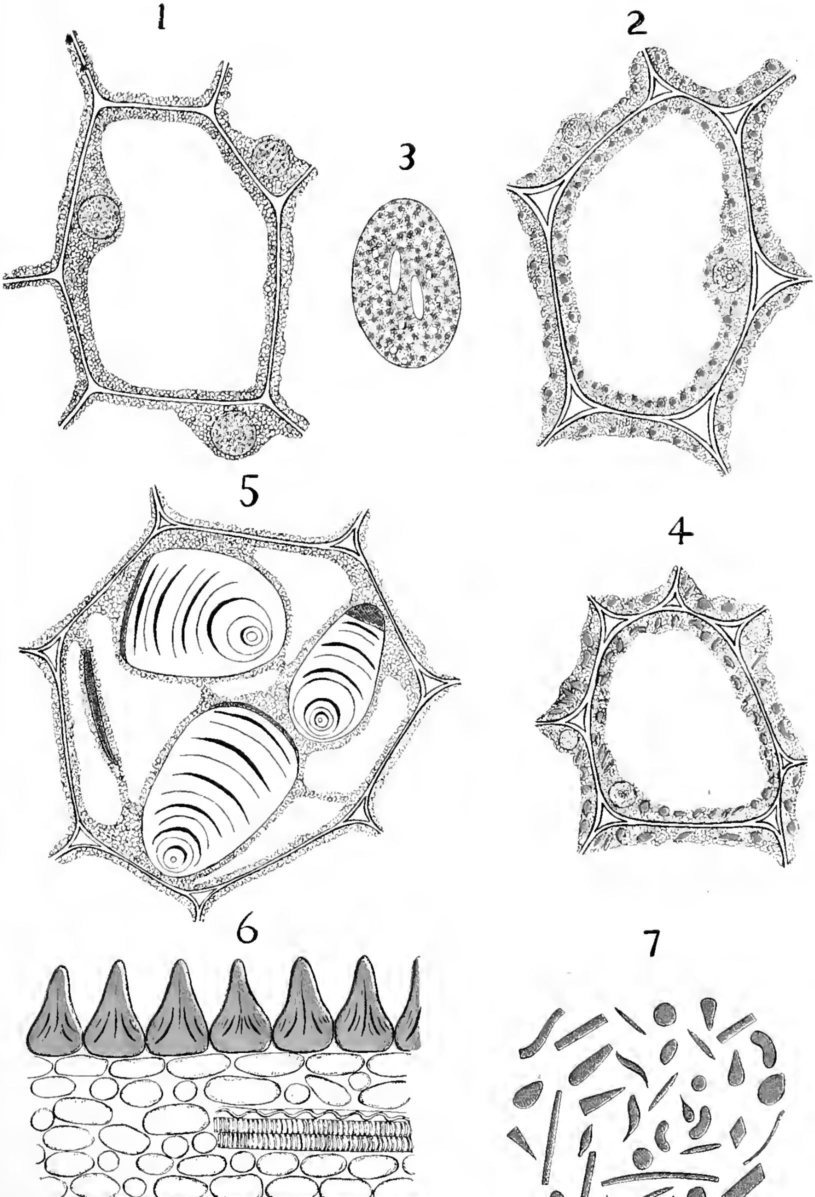

Plate II.

STARCH GRAINS.

Fig. 8.—Potato starch grains showing the excentral and circular point of origin of growth, and lamellæ.

Fig. 9.—Maranta starch grains showing fissured point of origin of growth, and distinct lamellæ.

Fig. 10.—Wheat starch grains showing indistinct point of origin of growth, and lamellæ.

Fig. 11.—Cornstarch grains, which are more or less polygonal in outline and have a 3 to 5-angled point of origin of growth.

Fig. 12.—Starch grains of *Iris Florentina* showing peculiar horse-shoe-like fissure extending from point of origin of growth.

Fig. 13.—Irregular starch grains of calumba root.

Fig. 14.—Peculiar beaked starch grains of ginger rhizome.

Fig. 15.—Starch grains of bean showing irregular longitudinal fissures.

Fig. 16.—Compound starch grains of oats.

Plate II.

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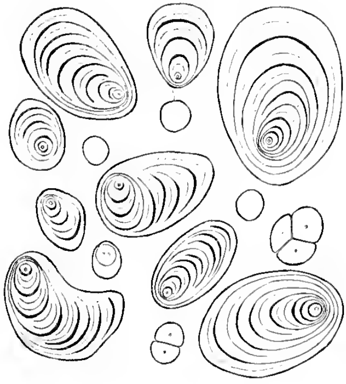

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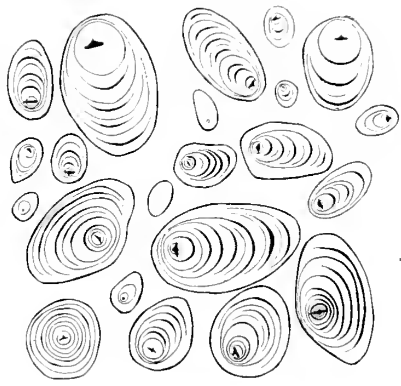

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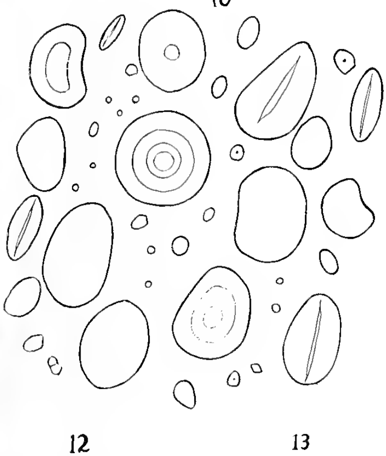

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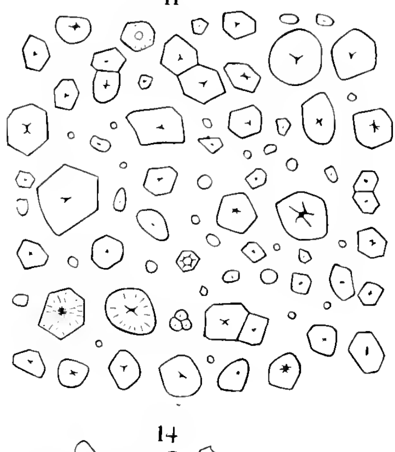

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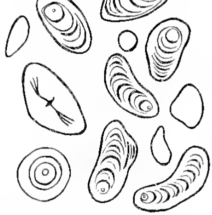

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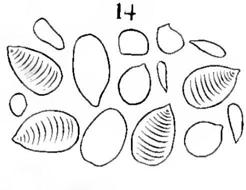

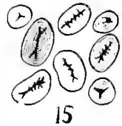

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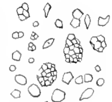

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Plate III.

CALCIUM-OXALATE CRYSTALS.

Fig. 17.—Transverse section of rheum showing rosette aggregates of calcium oxalate in three of the cells and starch grains in some of the others.

Fig. 18.—Longitudinal section of scilla showing raphides.

Fig. 19.—Longitudinal section of quillaja showing large monoclinic prisms and pyramids of calcium oxalate and also some starch grains.

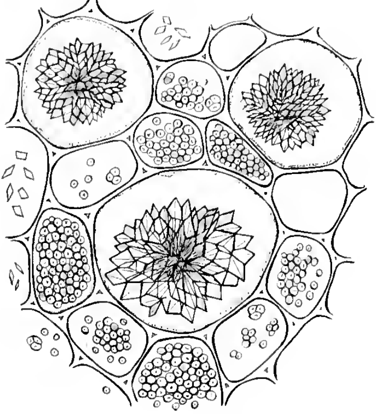
Fig. 20.—Transverse section of hyoscyamus leaf showing monoclinic prisms of calcium oxalate, also a twin crystal.

Fig. 21.—Longitudinal section of glycyrrhiza showing a crystal fiber, *i. e.*, a row of superimposed cells, each containing polygonal monoclinic prisms of calcium oxalate, the crystal filling the cell. Adjoining the crystal fiber is a group of bast fibers and some cells containing starch.

Fig. 22.—Transverse section of belladonna root showing one cell filled with cryptocrystalline crystals, the remaining cells containing starch.

Plate III.

17



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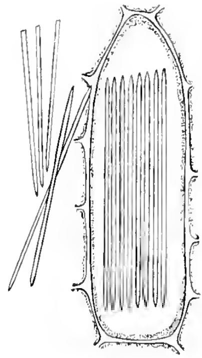

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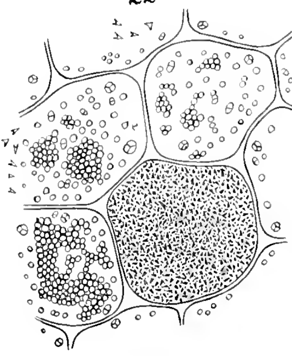

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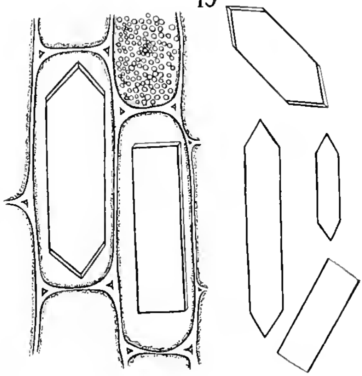

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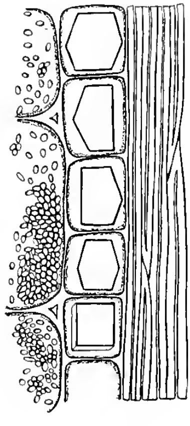

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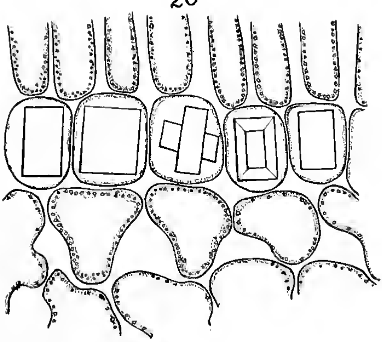

Plate IV.

FORMS OF CELLS.

Fig. 23.—Transverse section of the pith of *Tradescantia Virginica:* (I), intercellular space; (W), wall.

Fig. 24.—Transverse section of the stem of *Phytolacca decandra* showing collenchymatous cells beneath the epidermis.

Fig. 25.—Transverse section of calamus showing a large oil-secretion cell and smaller cells containing starch, and large intercellular spaces (I).

Fig. 26.—Transverse section of pyrethrum: (R), oil-secretion reservoirs with oil globules; (I), cells with sphere crystals of inulin, such as separate in alcoholic material; (L), cells containing irregular masses of inulin, as found in dried material.

Fig. 27.—Longitudinal section of *Cucurbita Pepo:* (S), sieve cell with protoplasm-like contents, and transverse walls (sieve plates) showing simple pores.

Fig. 28.—Longitudinal section of *Cucurbita Pepo* showing various forms of ducts: (A), annular; (S), spiral; (D), double spiral; (C), close annular; (R), reticulate.

Fig. 29.—Ducts of glycyrrhiza rhizome: (W), wall; (B), bordered pores; (P), oblique simple pores.

Fig. 30.—Longitudinal section of taraxacum showing branched laticiferous tissue (L).

Plate IV.

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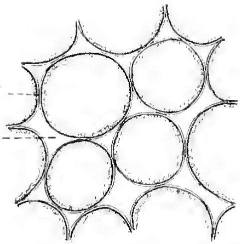

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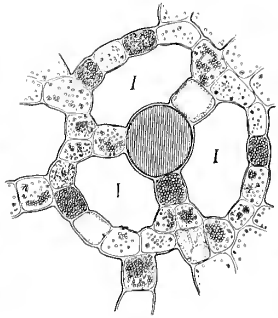

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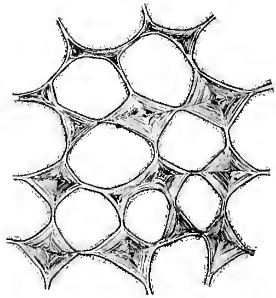

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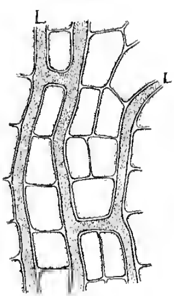

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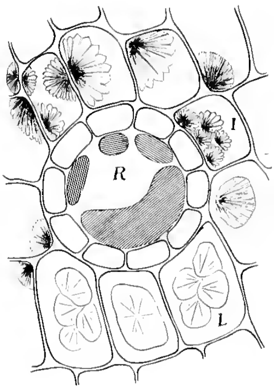

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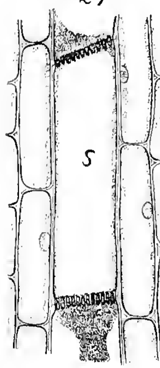

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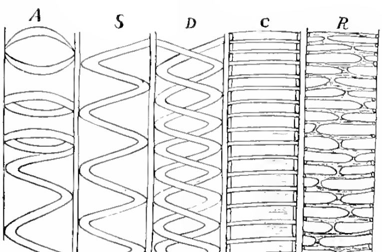

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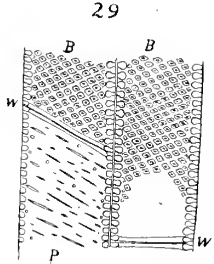

Plate V.

VARIOUS FORMS OF STONE CELLS.

Fig. 31.—From bark of Quercus alba.

Fig. 32.—From bark of *Canella alba.*

Fig. 33.—From seed-coat of capsicum.

Fig. 34.—Epidermis of hyoscyamus seeds.

Fig. 35.—From pericarp of pimenta, containing brownish tannin masses.

Fig. 36.—From seed-coat of coffee.

Fig. 37.—From seed-coat of almond.

Fig. 38.—Transverse section through stone cells of seed-coat of sinapis alba.

Fig. 39.—Surface view of stone cells of seed-coat of sinapis alba.

Fig. 40.—Transverse section through stone cells of endocarp of olive, the lumen containing air.

Fig. 41.—Transverse section through a stone cell in the periderm of calumba, the cell containing numerous monoclinic prisms of calcium oxalate.

Fig. 42.—Various forms of stone cells isolated from pericarp of illicium.

Plate V.

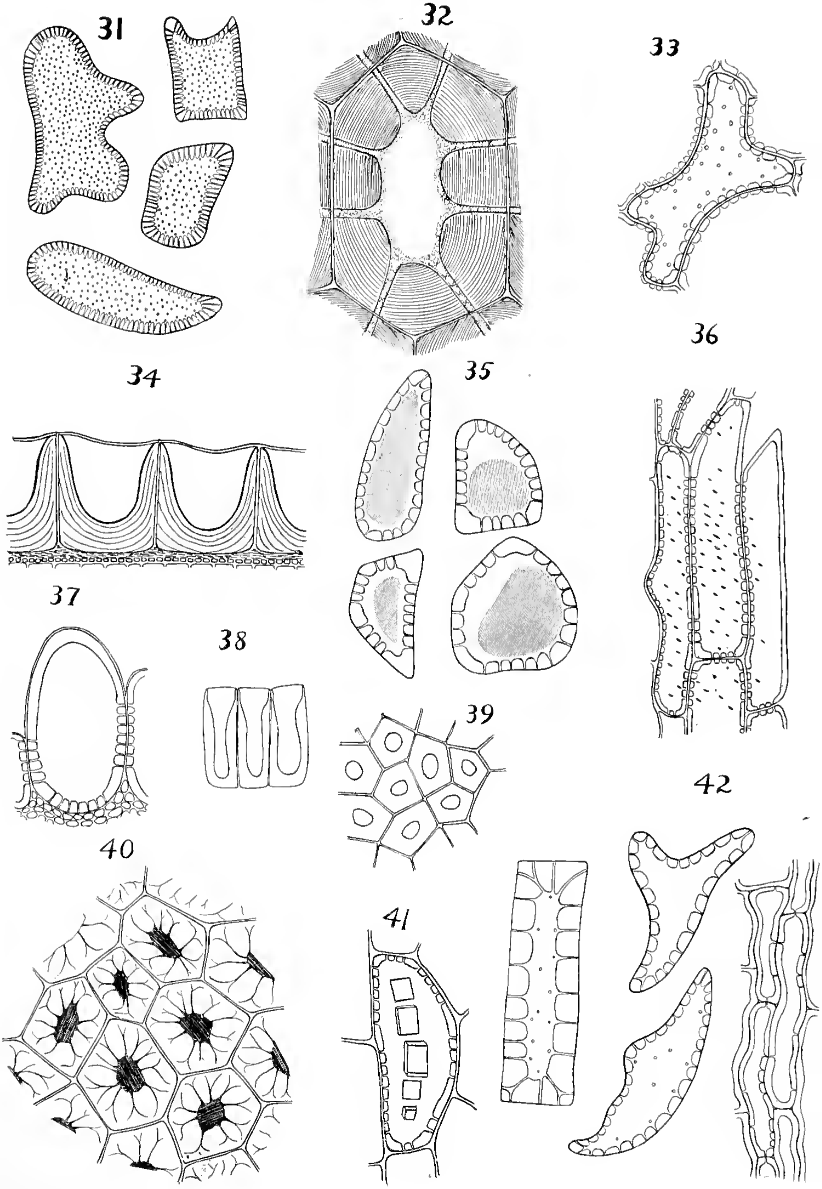

Plate VI.

VARIOUS FORMS OF SCLERENCHYMATOUS FIBERS.

Fig. 43.—Intermediate fibers from wood of ipecacuanha showing lignified walls with oblique simple pores and one cell containing starch.

Fig. 44.—Bast fibers from cinchona showing in transverse section a stratification of the wall, the isolated fibers showing striation of the walls.

Fig. 45.—Tracheids of quassia showing bordered pores and fragments of medullary-ray cells.

Fig. 46.—Intermediate fiber of gentian, the walls consisting of cellulose and having simple oblique pores.

Fig. 47.—Transverse section of a group of bast fibers in quercus alba, and a few crystal fibers.

Fig. 48.—Portions of two bast fibers from krameria.

Fig. 49.—Sclerenchymatous fiber from leaf of uva ursi.

Fig. 50.—Portion of modified bast fiber of euonymus.

Fig. 51.—Portions of bast fibers and a crystal fiber of quercus alba.

Fig. 52.—Portions of sclerenchymatous fibers of quillaja showing unequal thickening.

Fig. 53.—Portion of bast fiber of the root of a species of *Gossypium*.

Fig. 54.—Isolated sclerenchymatous fiber of zingiber.

Plate VI.

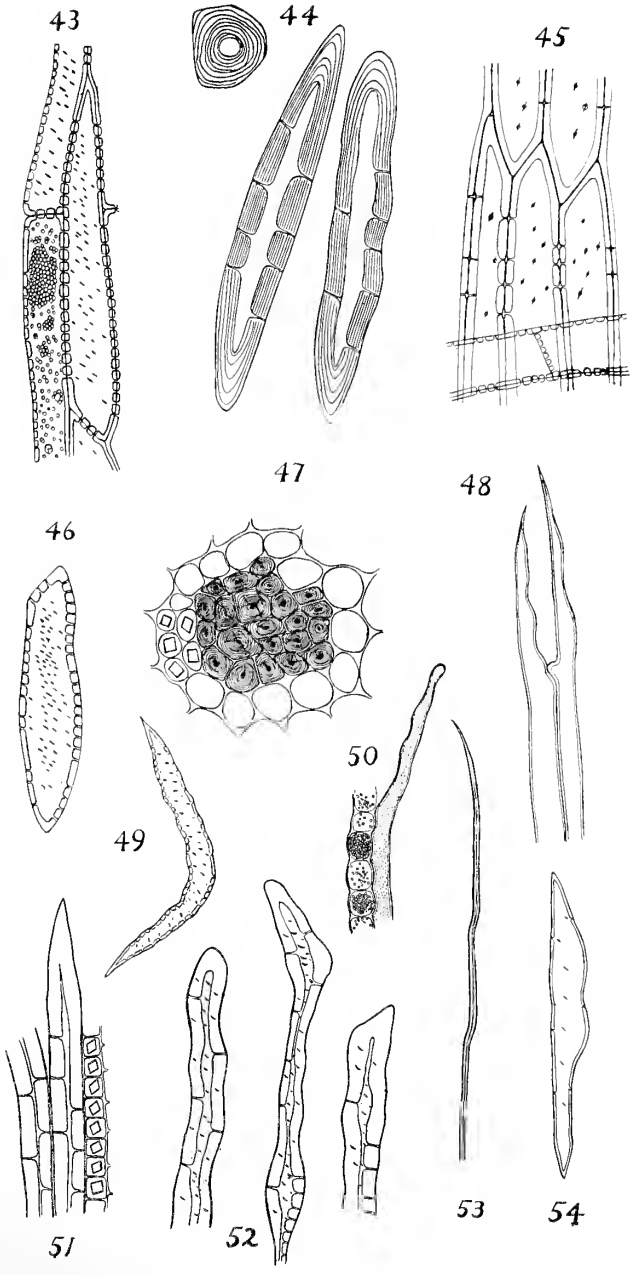

Plate VII.

MORPHOLOGY OF ROOTS AND STEMS.

Fig. 55.—A germinating plant of pea: (P), growing point of root protected by a root-cap; (RB), root branches in different stages of development; (HC), hypocotyl; (EC), epicotyl; (C), cotyledon.

Fig. 56.—A germinating plant of *Sinapis alba:* (P), growing point of root; (H), root hairs; (C), cotyledon.

Fig. 57.—A transverse section through the root of a germinating pea plant about 40 mm. from the tip showing the origin of a root branch; (E), epidermis; (CO), primary cortex; (X), xylem; (P), phloem; (EN), endodermis; (RB), root branch.

Fig. 58.—Longitudinal section through a root of *Veratrum viride* showing the nature of the contraction of the root: (E), epidermis; (CS), cells of cortex containing starch; (CO), cells of cortex containing raphides; (F), fibrovascular bundle; (A), rifts or cavities formed as a result of the radial swelling of the cells of the cortex.

Fig. 59.—Longitudinal section through winter bud of *Quercus coccinea:* (P), growing point; (L), young leaves; (SB), stem branches; (F), fibrovascular bundle.

PLATE VII.

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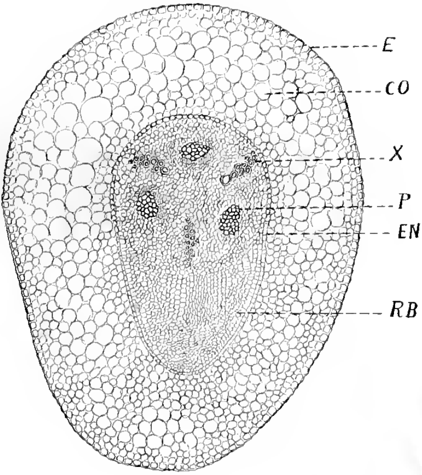

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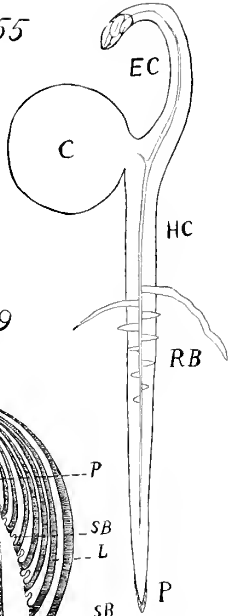

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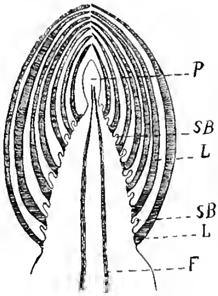

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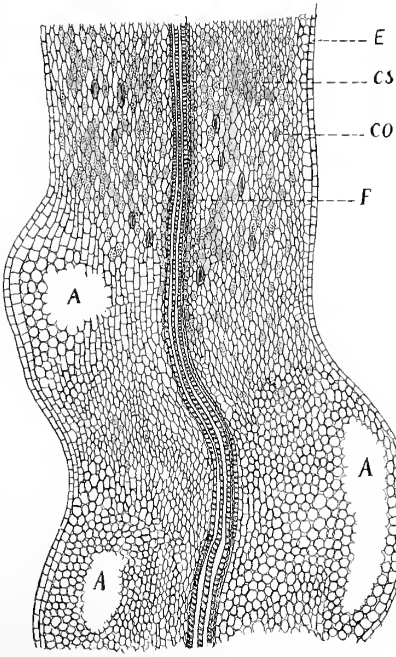

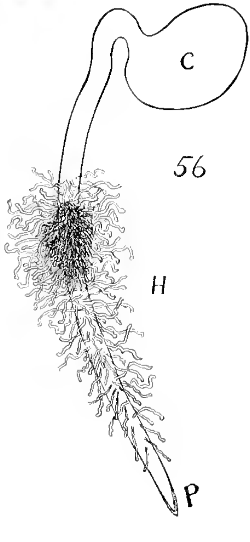

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Plate VIII.

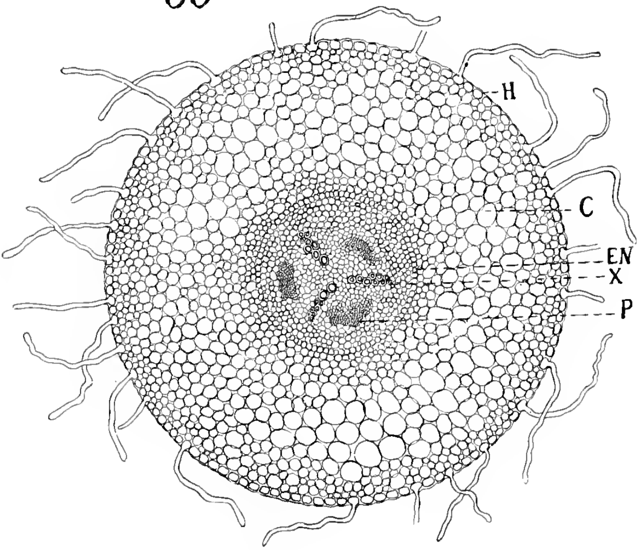
CHANGE FROM PRIMARY TO SECONDARY STRUCTURE IN THE ROOT.

Fig. 60.—Transverse section of root of pea about 40 mm. from the root-cap: (H), epidermal cells, some of which are developed to root hairs; (C), primary cortex; (EN), endodermis; (X), xylem; (P), phloem; the arrangement of sieve and ducts forming radial fibrovascular bundles.

Fig. 61.—Section in the older part, higher up on the root showing in addition to what has been observed in Fig. 60, the beginning of the change from primary to secondary structure: (CA), the development of a cambium; (SX), secondary xylem, and (SP), secondary phloem.

PLATE VIII.

60



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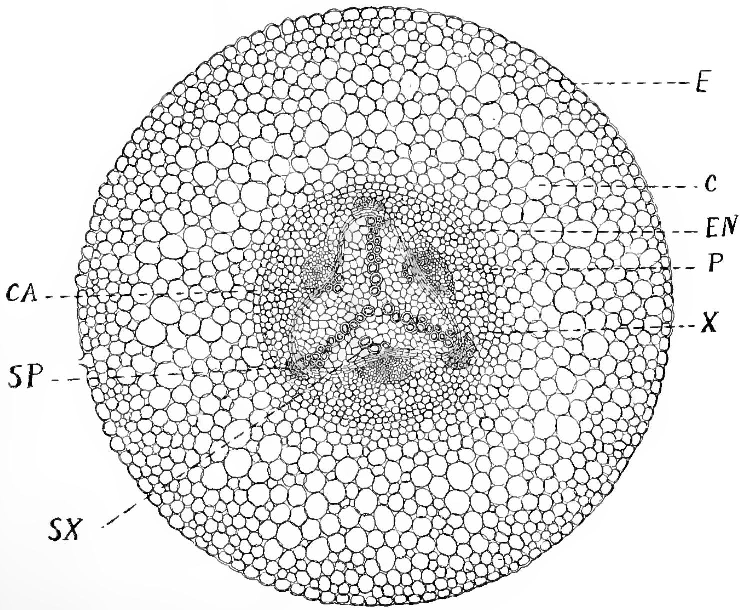

Plate IX.

FULLY DEVELOPED SECONDARY STRUCTURE IN ROOT.

Fig. 62.—Transverse section of root of pea at the end of the summer's growth: (E), some epidermal cells with fragments of root hairs; (C), primary cortex; (EN), endodermis; (K), cork: (B), bast fibers; (SC), secondary cortex; (S), sieve; (T), ducts; (W), wood fibers; (WP), wood parenchyma: (PM), primary medullary rays; (SM), secondary medullary rays; the arrangement of xylem and phloem forming collateral bundles.

PLATE IX.

62

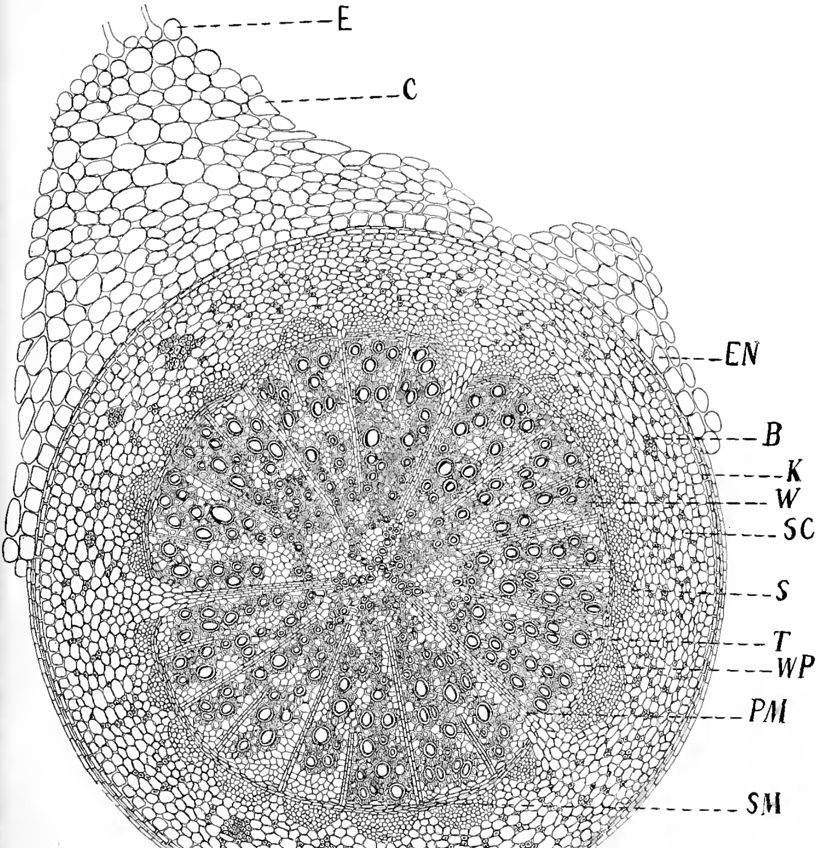

Plate X.

MONOCOTYLEDONOUS STEM STRUCTURE.

Fig. 63.—Transverse section of convallaria (rhizome): (E), epidermis; (H), hypodermis composed of collenchyma; (C), cortex; (EN), endodermis; (S), sieve; (T), ducts; (P), pith.

PLATE X.

63

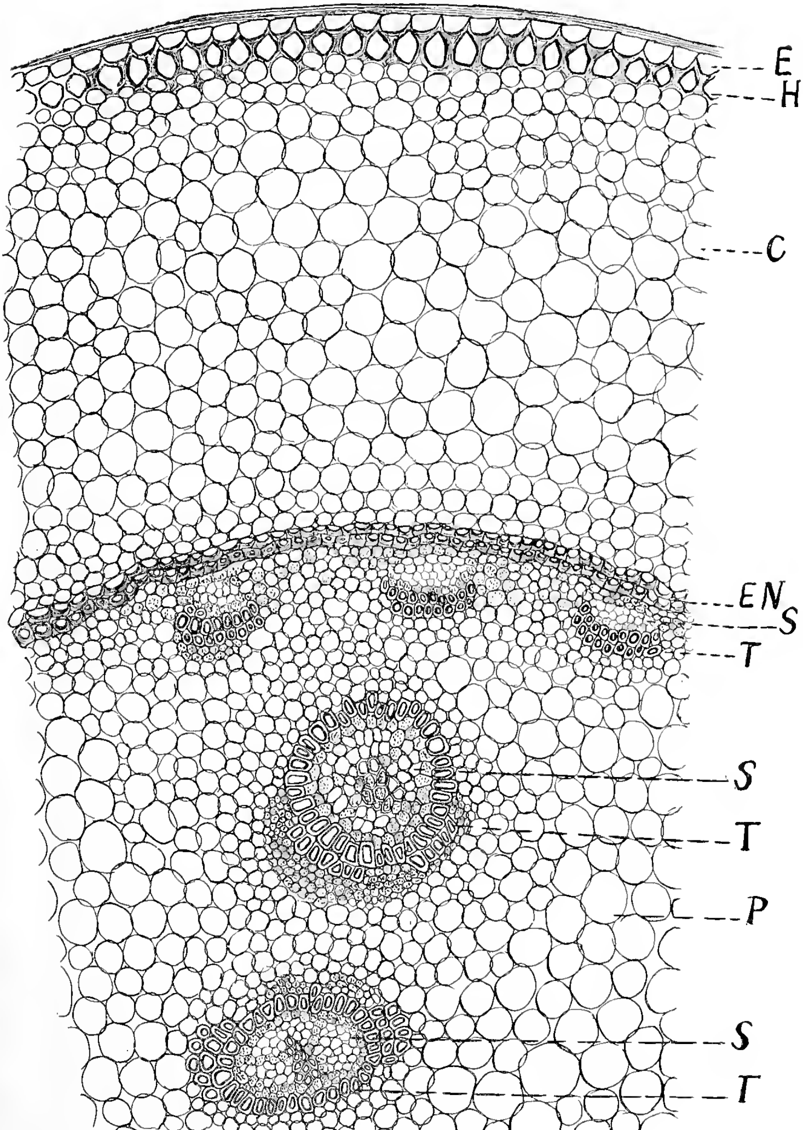

Plate XI.

DICOTYLEDONOUS STEM STRUCTURE.

Fig. 64.—Transverse section through menispermum (rhizome); (E), epidermis, which is being replaced by cork (K): (C), cortex; (B), bast fibers; (S), sieve; (ST), stone cells; (CA), cambium; (T), ducts; (W), wood fibers; (M) medullary rays; (P) pith.

Plate XI.

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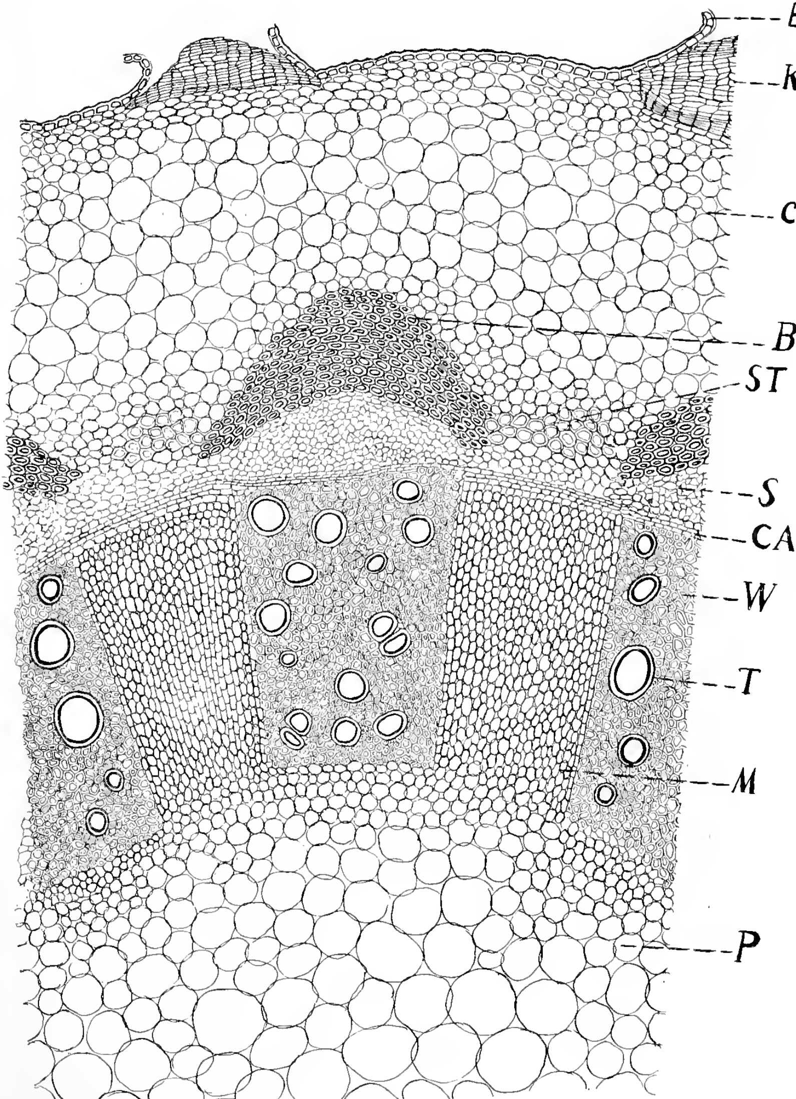


Plate XII.

MORPHOLOGY OF THE LEAF.

Fig. 65.—A leaf of *Viola tricolor* showing lamina, petiole, stipules and the distribution of the veins.

Fig. 66.—Transverse section of midrib of leaf of stramonium: (EU), upper epidermis; (CO), collenchyma; (PA), palisade cells; (O), layer of cells containing rosette-aggregates of calcium oxalate; (M), loose mesophyl; (EL), lower epidermis; (OP), prisms of calcium oxalate; (OS), cryptocrystalline crystals of calcium oxalate; (ST), stoma; (T), ducts; (SU), sieve on upper side of ducts; (SL), sieve on lower side of ducts; this arrangement of sieve and ducts forming bicollateral fibrovascular bundles.

Fig. 67.—Transverse section through lower surface of leaf of stramonium: stoma, with guard cells, (G); (N), surrounding cells; (A), intercellular cavity usually filled with cell sap or watery vapor; (E), epidermal cells.

Fig. 68.—Surface section of upper surface of leaf of *Viola tricolor* showing four stomata.

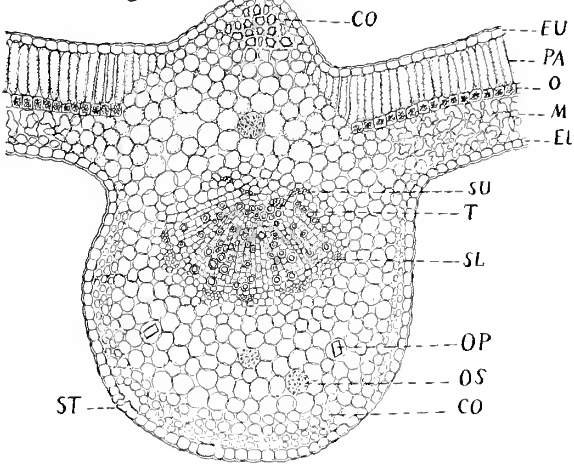
Fig. 69.—Surface section of under surface of leaf of *Viola tricolor* showing five stomata.

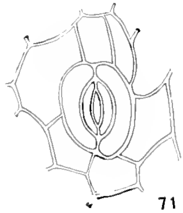
Fig. 70.—A section through the margin of the leaf of *Viola tricolor* showing a tooth with three water pores.

Fig. 71.—A water pore of *Viola tricolor* in surface section.

PLATE XII.

66





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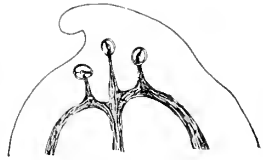

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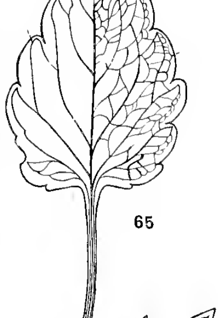

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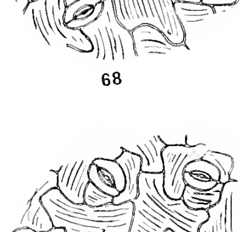

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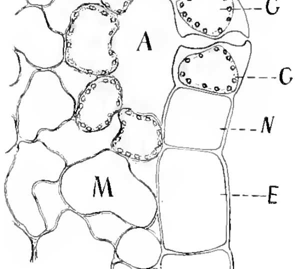

Plate XIII.

FORMS OF NON-SECRETION HAIRS.

Fig. 72.—Twisted hairs from under surface of leaf of eriodictyon.

Fig. 73.—Lignified hairs from the epidermis of nux vomica.

Fig. 74.—Branching hairs from the leaf of *Verbascum thapsus.*

Fig. 75.—Hair from the epidermis of strophanthus.

Fig. 76.—Non-secretion hairs from the capsule of *Mallotus Philippinensis* (found in the drug known as kamala).

Fig. 77.—Hairs from leaf of digitalis.

Fig. 78.—A hair from the under surface of the leaf of senna.

Fig. 79.—Hairs from the leaves and bracts of cannabis indica, two of them containing cystoliths of calcium carbonate.

Fig. 80.—Two forms of hairs from sage leaf.

Fig. 81.—Two forms of hairs from the leaves of absinthium, a T-non-secretion hair and a small secretion hair.

PLATE XIII.

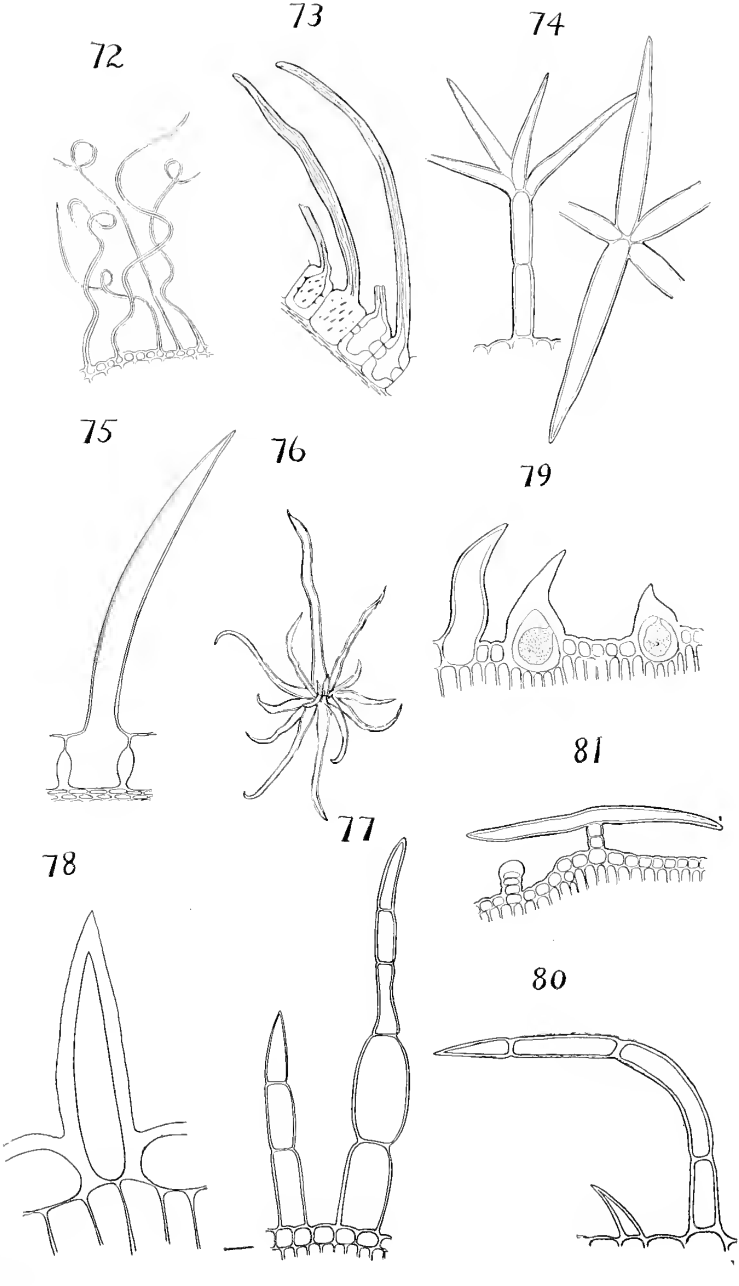

Plate XIV.

FORMS OF SECRETION HAIRS.

Fig. 82.—Corkscrew-like hair from the inner surface of the spurred corolla of lavender.

Fig. 83.—Longitudinal section of rhizome of *Dryopteris marginalis* showing large intercellular space and an internal oil-secretion hair.

Fig. 84.—Hairs from stramonium leaf.

Fig. 85.—Hairs from digitalis.

Fig. 86.—Hair from sage.

Fig. 87.—Large multicellular secretion hair from achene of humulus, the shaded portion showing the distended cuticle with oil.

Fig. 88.—Hair from eriodictyon.

Fig. 89.—Hairs from inner walls of pericarp of vanilla.

Fig. 90.—Hair from cannabis indica.

Fig. 91.—Hairs from surface of fruit of *Rhus glabra.*

Fig. 92.—Hairs from belladonna leaf.

PLATE XIV.

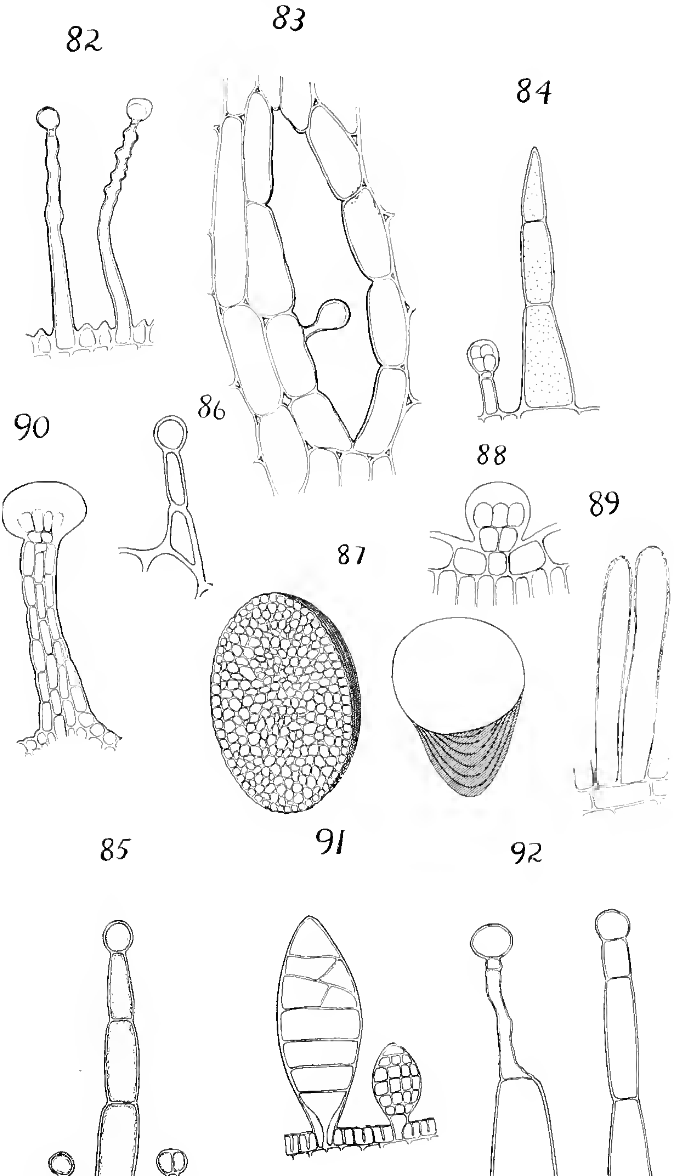

Plate XV.

MORPHOLOGY OF FLOWER OF VIOLA TRICOLOR.

Fig. 93.—Diagram of a flower: (X), the stem; (K), the leaf; (B), two bracts upon the flower stalk; then in successive circles, sepals, petals, stamens and the united pistils.

Fig. 94.—Longitudinal section through ovule showing the entrance of the pollen tube through the foramen to the embryo sac, the latter with a large number of nuclei; around the embryo sac is the nucellus, and around the latter are the two coats of the ovule, to the right being the raphe. (After Kny).

Fig. 95.—Epidermal cells from the outer surface of the spurred petal showing papillæ.

Fig. 96.—Epidermal cells from the under surface of the petals, some of the cells showing centripetal thickenings, the two without thickenings possessing sub-epidermal mucilage cells.

Fig. 97.—Epidermal cells from the under surface of the petals showing a zigzag outline and short centripetal thickenings.

Fig. 98.—Surface view of the mesophyl of the petals.

Fig. 99.—Corkscrew-like hair from the inner surface of the spurred corolla near the throat.

Fig. 100.—A hair from the edge of an anther.

Fig. 101.—Epidermal cells of the anthers.

Fig. 102.—Surface view of the mesophyl cells from the spurred stamen showing collenchymatous thickening.

Fig. 103.—Surface view of cells of endothecium.

Fig. 104.—Natural pollen grain viewed from the side.

Fig. 105.—Pollen grain examined in water.

Fig. 106.—Pollen grain observed in chloral solution.

Plate XV.

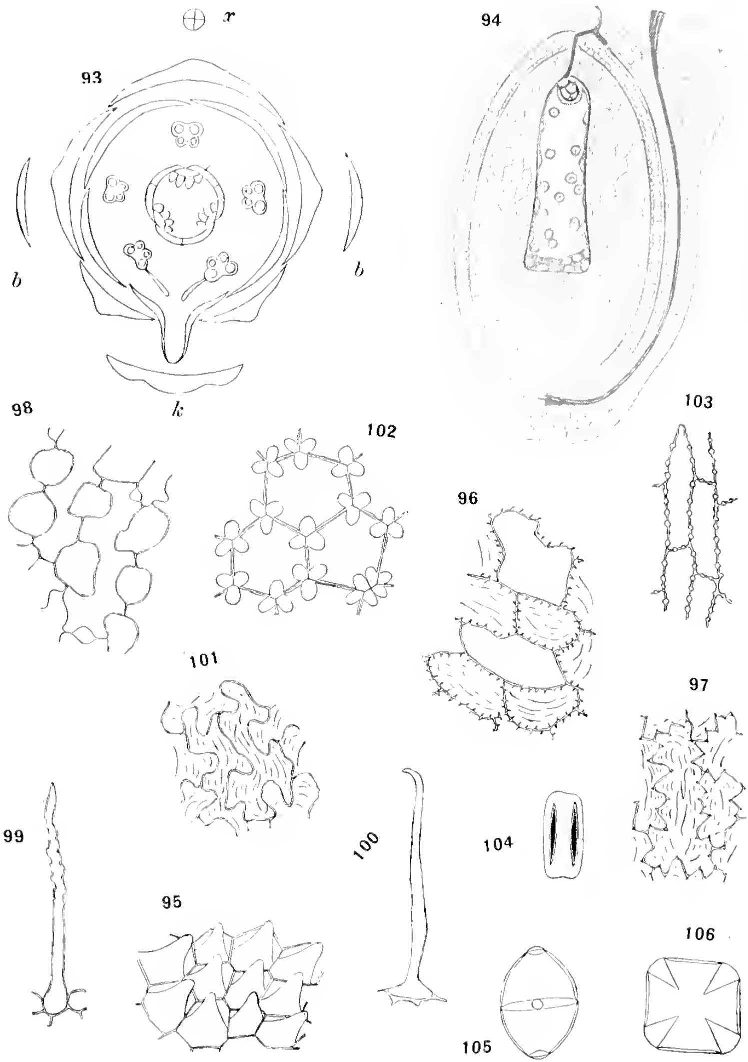

Plate XVI.

FLOWER AND FRUIT.

Fig. 107.—Transverse section through fruit of *Ricinis communis* showing septicidal dehiscence of capsule, the seeds (s) being borne on axial placentæ.

Fig. 108 —Transverse section through fruit of colocynth showing seeds (s) borne on parietal placentæ.

Fig. 109.—Transverse section through fruit of cardamom showing loculicidal dehiscence, the seeds, as in Fig. 107, being borne on axial placentæ.

Fig. 110.—Longitudinal section through orange flower: (PE), flower-stalk; (S), sepal; (P), petal; stamen with filament (f) and anther (a); united pistils with stigma (T), style (Y), and superior ovary (O) with ovules; (D), Disk.

Fig. 111.—Longitudinal section through caryophyllus showing inferior ovary (O), style (Y), stamen (F), petal (P), sepal (S), disk (D).

Fig. 112.—Ray flower of arnica: (P), ligulate corolla; (T), bifid stigma; (Y), style; (AC), inferior ovary, becoming an achene; (PA), pappus.

Fig. 113.—Disk flower of arnica: (P), tubular corolla; (A), anthers; (T), bifid stigma; (Y), style; (AC), inferior ovary, becoming an achene; (PA), pappus.

Fig. 113A.—Transverse section through anther of *Œnothera biennis* showing two lobes, each with two pollen sacs, one of these being ruptured.

Fig. 114.—Pollen grain of crocus.

Fig. 115.—Pollen grain of arnica, with three thin places in the wall for the germination of the pollen tube, the remainder of the wall with prominent centrifugal sculpturing.

Fig. 116 —Pollen grain of lavender showing six thin places in the wall for the germination of the pollen tube, the remainder of the wall being finely sculptured.

Fig. 117.—Overlapping hairs of pappus of arnica.

Fig. 118.—Superior dry drupe of cubeb with remnant of style at apex, a long stalk and orthotropous seed.

Fig. 119.—Inferior dry drupe of pimenta with remains of five calyx teeth at the apex and two cells each containing a seed.

Plate XVI.

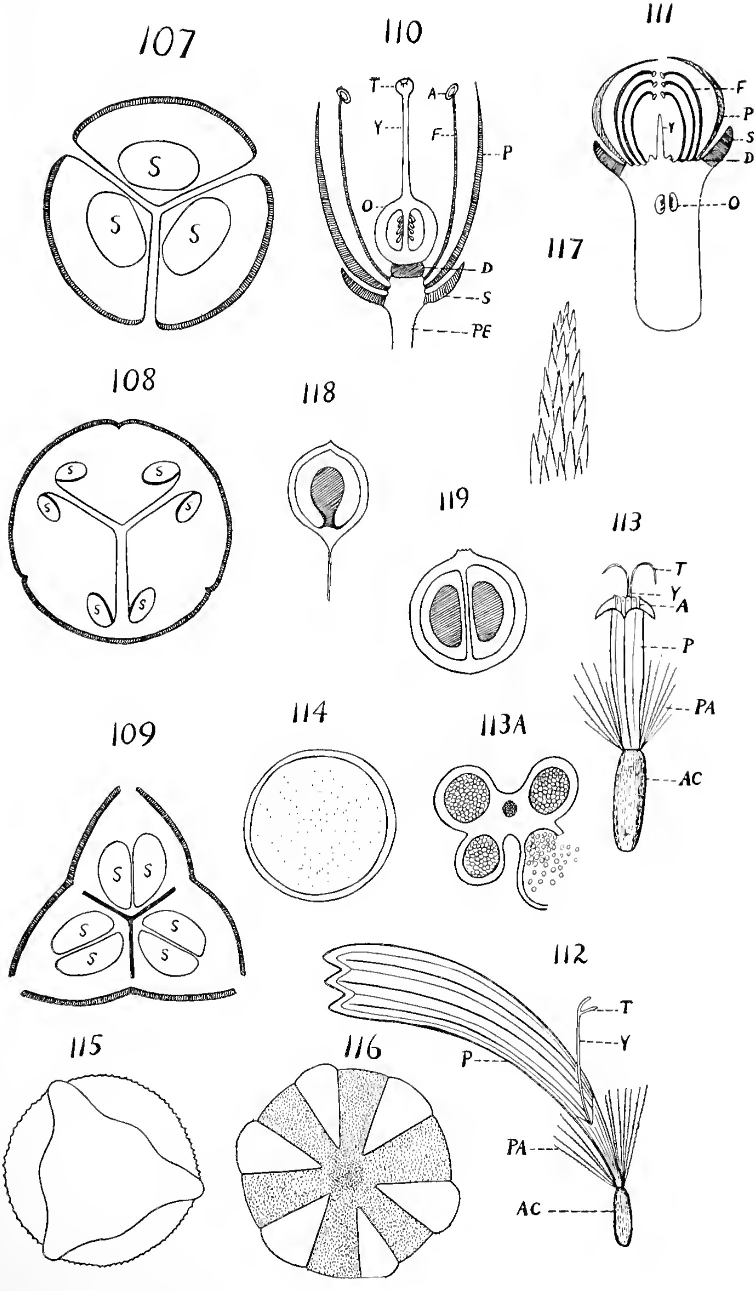

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Plate XVII.

FRUIT AND SEED.

Fig. 120.—Cremocarp of fennel: (C), carpophore; (M), mericarp; (R), primary ridges.

Fig. 121.—Transverse section through mericarp of fennel: (O), outer epidermis of pericarp; (I), inner epidermis of pericarp; (F), fibrovascular bundle; (V), vittæ; (S), seed-coat; (EN), endosperm; (C), section through the carpophore, which is composed chiefly of sclerenchymatous cells.

Fig. 122.—Isolated aleurone grains from cells of endosperm of fennel showing globoids and small rosette-aggregates of calcium oxalate.

Fig. 123.—Longitudinal section through anatropous seed of linum: (R), raphe; (SC), seed-coat; (M), hilum; (H), micropyle; (EN), endosperm; (C), cotyledon; (HY), hypocotyl.

Fig. 124.—Longitudinal section through stramonium seed: (SC), seed-coat; (H), micropyle; (M), hilum; (EN), endosperm; (E), embryo.

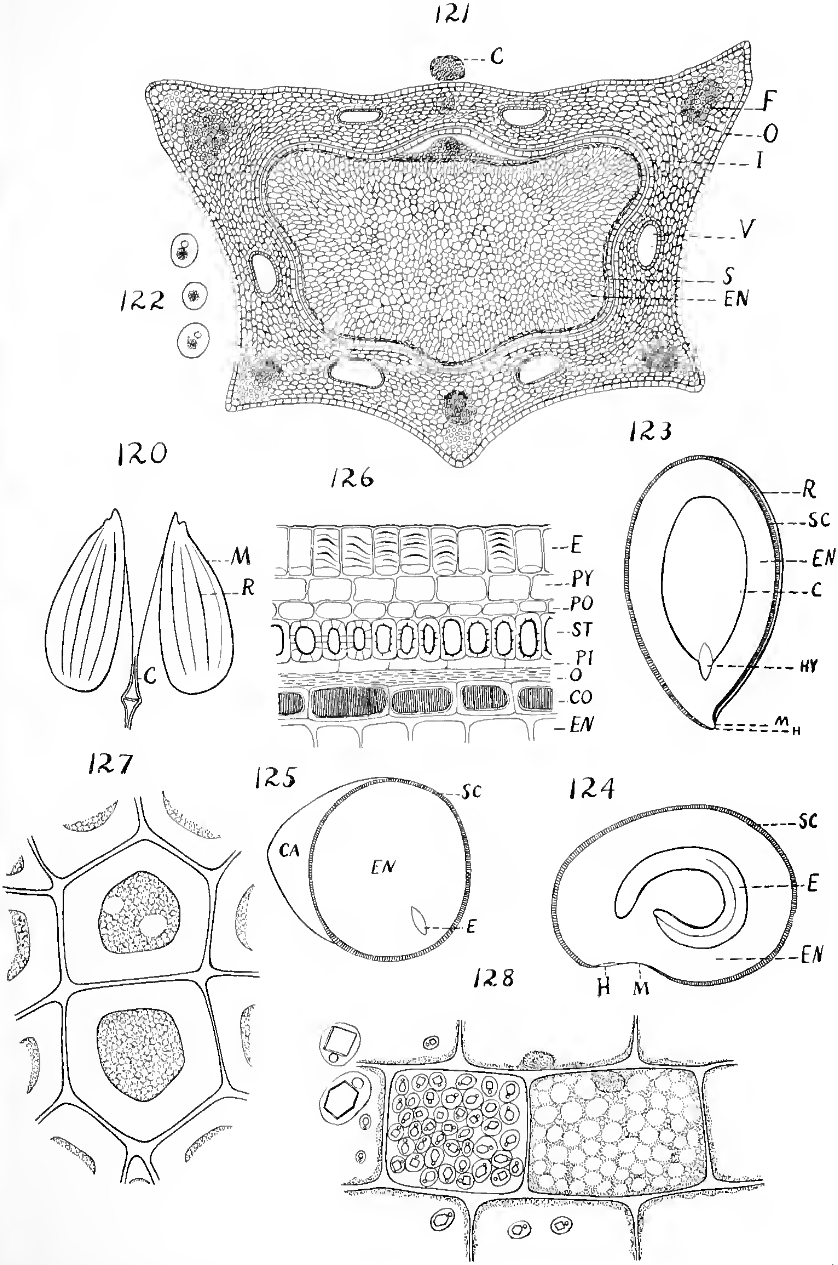
Fig. 125.—Longitudinal section through colchicum seed: (CA), caruncle; (SC), seed-coat; (EN), endosperm; (E), embryo.

Fig. 126.—Transverse section through seed-coat of linum: (E), epidermal cells with small lumen and very thick outer wall showing mucilage lamellæ; (PY), parenchyma-cells with yellowish walls; (PO), parenchyma above the layer of stone cells; (ST), stone cells; (PL), parenchyma below stone cells; (O), obliterated cells; (CO), cells with reddish-brown contents; (EN), endosperm.

Fig. 127.—Transverse section through endosperm of nux vomica showing thick-walled parenchyma, the cells containing oil and protoplasm.

Fig. 128.—Transverse section through endosperm of seed of *Ricinus communis,* one cell filled with aleurone grains consisting of crystalloid and globoid, the other in which the aleurone grains have been dissolved but leaving the protoplasm and nucleus.

Plate XVII.



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